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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LXV.

FEBRUARY 10, 1905.

No. 4

ANNUAL GENERAL MEETING.

Professor H. H. TURNER, D.Sc., F.R.S., PRESIDENT, in the Chair.

The Report of the Auditors of the Treasurer's accounts for the year 1904 was read, and is given on p. 326.

The Annual Report of the Council was partly read; see pp. 323 to 411.

The Address was delivered by the President, after which the Gold Medal was handed to His Excellency the American Ambassador for transmission to Professor Lewis Boss, to whom the Medal had been awarded for his long-continued work on the positions and proper motions of Fundamental Stars (see pp. 412 to 425).

The President also announced that the Jackson-Gwilt Gift and Bronze Medal had been awarded to Mr. John Tebbutt, of Windsor, New South Wales, for his important observations of Comets and Double Stars, and his long-continued services to astronomy in Australia, extending over forty years. The Medal was then handed to the Secretary for transmission to Mr. Tebbutt.

The President handed to the Assistant Secretary a cheque for 140*l.* as a testimonial from the Fellows of their appreciation of his devotion to the service of the Society for the past thirty years.

The President having appointed the Scrutineers, the Society proceeded to the ballot for Officers and Council for the ensuing year. The names of those elected are given on p. 426.

The thanks of the Meeting were given to the retiring Officers, and also to the Auditors of the Treasurer's Accounts and to the Scrutineers of the ballot.

William Edward Raymond, Astronomical Observer, Sydney Observatory, New South Wales, Australia,
was balloted for and duly elected a Fellow of the Society.

The following Candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

- William Bowyer, Established Computer, Royal Observatory, Greenwich (proposed by Thomas Lewis) ;
- Rev. Thomas Joseph Charlton, The Rectory, Omeath, Co. Louth, Ireland (proposed by Dr. J. S. Slater) ;
- Captain Louis Arthur D'Emres, Chief Examiner for Masters and Mates, Marine and Fisheries Department, Ottawa, Canada (proposed by Captain P. Thompson) ;
- David James Reginald Edney, Established Computer, Royal Observatory, Greenwich, Teston Lodge, Blackheath Rise, Lewisham, S.E. (proposed by W. W. Bryant) ;
- Herbert Henry Furner, Established Computer, Royal Observatory, Greenwich (proposed by F. W. Dyson) ;
- John Adelbert Parkhurst, M.Sc., Yerkes Observatory, Williams Bay, Wis., U.S.A. (proposed by H. H. Turner) ;
- Montagu Austin Phillips, 22 Petherton Road, Highbury New Park, N. (proposed by F. W. Levander) ; and
- A. L. Wood, Teacher of Navigation, H.M.S. "Conway," Rock Ferry, Birkenhead (proposed by W. G. Thackeray).

REPORT OF THE COUNCIL TO THE EIGHTY-FIFTH ANNUAL
GENERAL MEETING OF THE SOCIETY.

The following table shows the progress and present state of the Society :—

	Compounders	Annual Subscribers	Total Fellows	Associates	Patron and Hon. Members	Grand Total
1903 December 31	266	377	643	47	3	693
Since elected	+ 2	+ 29	...	+ 3	...	...
Deceased	- 9	- 11	...	- 1	...	...
Resigned	...	- 7	...	...	...	...
Removals	+ 3	- 3	...	...	...	...
Expelled	...	- 3	...	...	...	...
1904 December 31	262	382	644	49	3	696

Mr. Maw's Account as Treasurer of the Royal

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RECEIVED.				£	s.	d.	£	s.	d.
Balances, 1903 December 31:—									
At Bankers', as per Pass-book				246	9	5			
Country Cheque not credited till 1904				9	16	0			
In hand of Assistant Secretary on Petty Cash Account				4	10	10			
							260	16	3
Dividends on £1,250 Metropolitan 3-per-cent. Stock				35	13	5			
Dividends on £932 19 0 Metropolitan 2½-per-cent. Stock				22	3	9			
Dividends on £3,400 East Indian Railway 3-per-cent. Debenture Stock				97	0	1			
Dividends on £3,200 London and North-Western Railway 3-per-cent. Debenture Stock				91	10	0			
Dividends on £4,000 Midland Railway 2½-per-cent. Debenture Stock				95	6	3			
Dividends on £500 Lancashire and Yorkshire Railway 3-per-cent. Consolidated Preference Stock				14	5	11			
Dividends on £1,860 Gas Light and Coke Co. 3-per-cent. Debenture Stock				53	3	8			
Dividends on £1,650 Commercial Gas Co. 3-per-cent. Debenture Stock				47	1	6			
Interest on sums on Deposit at Bankers'				2	17	3			
							459	1	10
Received on account of Subscriptions:—									
Arrears				121	16	0			
Annual Contributions for 1904				564	18	0			
" " in advance				2	2	0			
Admission Fees				63	0	0			
First Contributions				47	5	0			
							799	1	0
Composition Fees							105	0	0
Sales of Publications, &c.:—									
At Williams & Norgate's, 1903				9	4	5			
At Society's Rooms, 1904				68	2	0			
Sales of Photographs				32	7	0			
							109	13	5
Income Tax refunded by Commissioners of Inland Revenue							23	5	9
Rev. W. Sidgreaves: Contribution to cost of Plates				3	2	6			
Exors. of Sir C. Peek: Contribution to cost of vol. of <i>Memoirs</i>				200	0	0			
							203	2	6
Due to Assistant Secretary on Petty Cash Account							9	10	0

Audited and found correct, 1905 Jan. 9:

C. THWAITES.
WALTER W. BRYANT.
WM. SHACKLETON.

£1,969 10 9

Astronomical Society, from 1904 January 1 to December 31.

PAID.

	£	s.	d.	£	s.	d.
Assistant Secretary: Salary	250	0	0			
" " For editing Society's Publications	50	0	0			
" " Special grant	10	0	0			
				310	0	0
House Duty	2	12	6			
Fire Insurance	9	9	6			
				12	2	0
Printing, plates, &c., <i>Memoirs</i> , vol. liv. (Spottiswoode & Co.)	203	13	6			
Printing, plates, &c., <i>Monthly Notices</i> (Spottiswoode & Co.)	540	6	3			
Printing, plates, &c., Appendix to <i>Memoirs</i> (Harrison & Sons)	66	12	10			
Printing, plates, &c., Appendix to <i>Monthly Notices</i> (Harrison & Sons)	14	7	0			
Printing List of Fellows and Miscellaneous (Spottiswoode & Co.)	29	16	6			
Photo-plates for <i>Monthly Notices</i> (A. E. Dent & Co.)	17	17	11			
				872	14	0
Computation of Ephemerides in <i>Monthly Notices</i>				15	0	0
Purchase of books for Library: from Council Grant	10	0	0			
Do. from Turnor and Horrox Fund	6	14	0			
				16	14	0
Binding books in Library				45	8	6
Reproduction of Photographs, Hinton & Co.				42	4	8
Cataloguing astronomical literature for the International Catalogue				30	0	0
Clerk's Wages	53	0	0			
Postage and Telegrams	92	3	8			
Carriage of Parcels, &c.	9	13	8			
Stationery (Spottiswoode & Co.)	8	14	3			
Sundry Stationery and Office Expenses	4	3	9			
				167	15	4
Expenses of Meetings	21	14	0			
Lantern Expenses	10	16	5			
Time Signal: Rental of Wire	5	0	0			
				37	10	5
House Expenses	62	15	6			
Coal and Gas	39	14	8			
Electric Light Expenses	6	10	6			
Fittings, Repairs, &c.	22	12	1			
Sundry ditto	8	18	5			
Sundries	4	15	7			
				145	6	9
Lee and Janson Fund: grant to Mrs. Hopkins				10	0	0
Deductions on Cheques, &c.				0	1	8
Repayment to Assistant Secretary of amount due 1903 Dec. 31 on Account of Turnor and Horrox Fund				2	8	3
Balances, 1904 December 31:—						
At Bankers', as per Pass-book	252	7	5			
In hand of Assistant Secretary on Account of Turnor and Horrox Fund... ..	9	17	9			
				262	5	2
				<u>£1,969</u>	<u>10</u>	<u>9</u>

Report of the Auditors.

We have examined the Treasurer's accounts of receipts and expenditure for the year 1904, and have found and certified the same to be correct. The cash in hand on December 31, 1904, including the balance at the bankers', &c., amounted to £262 5s. 2d.

The invested property of the Society is the same as at the end of the previous year.

The books, instruments, and other effects in the possession of the Society have been examined, and they appear to be in a satisfactory condition.

We have laid on the table a list of the names of those Fellows who are in arrear for sums due at the last Annual General Meeting of the Society, with the amount due against each Fellow's name.

(Signed)

C. THWAITES.

WALTER W. BRYANT.

WM. SHACKLETON.

1905 January 13.

Trust Funds.

The Turnor Fund: A sum of £464 18s. East Indian Railway 3-per-cent. Debenture Stock; the interest to be used in the purchase of books for the Library.

The Horrox Memorial Fund: A sum of £103 6s. East Indian Railway 3-per-cent. Debenture Stock; the interest to be used in the purchase of books for the Library.

The Lee and Janson Fund: A sum of £334 10s. 9d. East Indian Railway 3-per-cent. Debenture Stock; the interest to be given by the Council to the widow or orphan of any deceased Fellow of the Society who may stand in need of it.

The Hannah Jackson (née Gwilt) Fund: A sum of £309 18s. 6d. East Indian Railway 3-per-cent. Debenture Stock; the interest to be given in Medals or other awards, in accordance with the terms of the Trust.

Assets and Present Property of the Society, 1905 January 1.

	£	s.	d.	£	s.	d.
Balances, 1904 December 31:—						
At Bankers', as per Pass-book	252	7	5			
In hand of Assistant Secretary on account of Turnor and Horrox Fund... ..	9	17	9			
	262	5	2			
Less due to Assistant Secretary on Petty Cash Account	9	10	0			
				252	15	2
Due on account of Subscriptions:—						
1 Subscription of 5 years' standing	10	10	0			
4 " 4 " 	33	12	0			
12 " 3 " 	75	12	0			
36 " 2 " 	151	4	0			
56 " 1 year's standing	117	12	0			
4 Admission Fees and First Contributions	12	12	0			
	401	2	0			
Less 1 Subscription paid in advance	2	2	0			
				399	0	0
Due for Photographs sold				0	11	0
Due from Messrs. Williams & Norgate for sales of Publications during 1904				33	18	6
£3,400 East Indian Railway 3-per-cent. Debenture Stock, including the Turnor Fund, the Horrox Memorial Fund, the Lee and Janson Fund, and the Hannah Jackson (née Gwilt) Fund.						
£3,200 London and North-Western Railway 3-per-cent. De- benture Stock.						
£4,000 Midland Railway 2½-per-cent. Debenture Stock.						
£1,860 Gas Light and Coke Co. 3-per-cent. Debenture Stock.						
£1,650 Commercial Gas Company 3-per-cent. Debenture Stock.						
£500 Lancashire and Yorkshire Railway 3-per-cent. Consolidated Preference Stock.						
£1,250 Metropolitan 3-per-cent. Stock.						
£932 19s. 0d. Metropolitan 2½-per-cent. Stock.						
Astronomical and other Manuscripts, Books, Prints, and Instru- ments.						
Furniture, &c.						
Stock of Publications of the Society.						
Two Gold Medals.						

Celestial Photographs.

The following is a list of reproductions of Celestial Photographs published by the Royal Astronomical Society for sale to the Fellows :—

R.A.S. Ref. No.	Subject.	Photographed by
1	Total Solar Eclipse, 1889 January 1	W. H. Pickering
2	Total Solar Eclipse, 1893 April 16	J. M. Schaeberle
3	Total Solar Eclipse, 1886 August 29	A. Schuster
4	Nebulæ in the <i>Pleiades</i>	Isaac Roberts
5	Nebula M 74 <i>Piscium</i> (N.G.C. 628)	Isaac Roberts
6	Great Nebula in <i>Orion</i>	Isaac Roberts
7	Milky Way near M 11	E. E. Barnard
8	Milky Way near Cluster in <i>Perseus</i>	E. E. Barnard
9	Comet c 1893 IV. (Brooks), 1893 October 21	E. E. Barnard
10	Comet a 1892 I. (Swift), 1892 April 7	E. E. Barnard
11	Nebula about η <i>Argûs</i>	David Gill
12	Portion of Moon (Hyginus-Albategnius)	Loewy and Puiseux
13	Comet c 1893 IV. (Brooks), 1893 October 22	E. E. Barnard
14	Comet c 1893 IV. (Brooks), 1893 October 20	E. E. Barnard
15	Comet c 1893 IV. (Brooks), 1893 November 10	E. E. Barnard
16	Comet a 1892 I. (Swift), 1892 April 26	E. E. Barnard
17	Comet f 1892 III. (Holmes), 1892 November 10	E. E. Barnard
18	Comet a 1892 I. (Swift), 1892 April 18	E. E. Barnard
19	Portion of Moon (Alps, Apennines, &c.)	Loewy and Puiseux
20	Nebula in <i>Andromeda</i>	Isaac Roberts
21	<i>Jupiter</i> , 1892 September 26	Lick Observatory
22	Cluster M 13 <i>Herculis</i> (N.G.C. 6205)	W. E. Wilson
23	Total Solar Eclipse, 1893 April 16 (5 sec.)	J. Kearney
24	Total Solar Eclipse, 1893 April 16 (20 sec.)	J. Kearney
25	The Moon (Age 7 ^d 3 ^h)	Lick Observatory
26	The Moon (Age 12 ^d 6½ ^h)	Lick Observatory
27	The Moon (Age 16 ^d 18 ^h)	Lick Observatory
28	The Moon (Age 23 ^d 8 ^h)	Lick Observatory
29	The Sun, 1892 February 13	Roy. Obs., Greenwich
30	The Sun, 1892 July 8	Roy. Obs., Greenwich
31	Portion of Moon (Region of Maginus)	Loewy and Puiseux
32	The Moon (Age 14 ^d 1 ^h)	Lick Observatory
33	Portion of Moon (Ptolemæus, &c.)	Lick Observatory

R.A.S. Ref. No.	Subject.	Photographed by
34	Portion of Moon (Mare Serenitatis)	Lick Observatory
35	Portion of Moon (Clavius, Licetus, &c.)	Lick Observatory
36	Portion of Moon (Regiomontanus, &c.)	Lick Observatory
37	Portion of Moon (Tycho, Thebit, &c.)	Lick Observatory
38	Portion of Moon (Theophilus, &c.)	Lick Observatory
39	Total Solar Eclipse, 1896 August 9 (3 sec.)	S. Kostinsky
40	Total Solar Eclipse, 1896 August 9 (26 sec.)	A. Hansky
41	Cluster M 56 <i>Lyræ</i> (N.G.C. 6779)	
42	Nebulæ M 81, 82 <i>Ursæ Majoris</i> . (N.G.C. 3031, 3034)	
43	Cluster M 56 <i>Lyræ</i> (enlarged) (N.G.C. 6779)	
44	Solar Corona, 1871 December 12, Baikul	H. Davis
45	Solar Corona, 1875 April 6, Siam	Lockyer and Schuster
46	Solar Corona, 1878 July 29, Wyoming	W. Harkness
47	Solar Corona, 1882 May 17, Egypt	Abney and Schuster
48	Solar Corona, 1883 May 6, Caroline Island	Lawrance and Woods
49	Solar Corona, 1885 September 9, Wellington, N.Z.	Radford
50	Solar Corona, 1886 August 29, Grenada, W.I.	A. Schuster
51	Solar Corona, 1887 August 19, Japan	M. Sugiyama
52	Solar Corona, 1889 January 1, California	W. H. Pickering
53	Solar Corona, 1889 December 22, Cayenne	J. M. Schaeberle
54	Solar Corona, 1893 April 16, Fundium	J. Kearney
55	Solar Corona, 1893 April 16, Brazil	A. Taylor
56	Great Nebula in <i>Orion</i>	W. E. Wilson
57	Dumb-bell Nebula, <i>Vulpecula</i> (N.G.C. 6853)	W. E. Wilson
58	Spiral Nebula, <i>Canes Venatici</i> (N.G.C. 5194)	W. E. Wilson
59	Ditto (enlarged) (N.G.C. 5194)	W. E. Wilson
60	Annular Nebula, <i>Lyra</i> (N.G.C. 6720)	W. E. Wilson
61	Meteor Trail and Comet Brooks, 1893 November 13	E. E. Barnard
62	Total Solar Eclipse, 1898 January 22 (5 sec.)	W. H. M. Christie
63	Total Solar Eclipse, 1898 January 22 (20 sec.)	W. H. M. Christie
64	Solar Corona, 1896 August 9, Novaya Zemlya	G. Baden-Powell
65	Solar Corona, 1898 January 22, Pulgaon, India	E. H. Hills
66	Nebula in <i>Andromeda</i>	Roy. Obs., Greenwich
67	Spectrum of Sun's limb, 1898 January 22	E. H. Hills
68	Annular Nebula, <i>Lyra</i> (N.G.C. 6720)	Lick Observatory
69	Dumb-bell Nebula, <i>Vulpecula</i> (N.G.C. 6853)	Lick Observatory
70	Spiral Nebula, <i>Canes Venatici</i> (N.G.C. 5194-5)	Lick Observatory
71	Spiral Nebula, <i>Ursa Major</i> (N.G.C. 5457)	Lick Observatory
72	Trifid Nebula, <i>Sagittarius</i> (N.G.C. 6514)	Lick Observatory

R.A.S. Ref. No.	Subject.	Photographed by
73	Great Nebula in <i>Orion</i>	Lick Observatory
74	Cluster M 13 <i>Herculis</i> (N.G.C. 6205)	Lick Observatory
75	Solar Surface with Faculæ	G. E. Hale
76	Faculæ and Prominences	G. E. Hale
77	Total Solar Eclipse, 1898 Jan. 22 ($\frac{2}{3}$ sec.)	W. H. M. Christie
78	Nebula H V. 14 <i>Cygni</i> (N.G.C. 6992)	W. E. Wilson
79	Portion of Moon (Theophilus, &c.)	Yerkes Observatory
80	Total Solar Eclipse, 1900 May 28 (30 sec.)	E. E. Barnard
81	Comet 1901 I., 1901 May 4	Roy. Obs., Cape of G. H.
82	Comet 1901 I., 1901 May 6	Roy. Obs., Cape of G. H.
83	Comet 1901 I., 1901 May 9	Perth Obs., W. Australia
84	Solar Surface with Faculæ	H. Deslandres
85	Solar Prominences	H. Deslandres
86	Nebula about Nova <i>Persei</i> , 1901 September 20	G. W. Ritchey
87	Nebula about Nova <i>Persei</i> , 1901 November 13	G. W. Ritchey
88	Total Solar Eclipse, 1901 May 18 (10 sec.)	F. W. Dyson
89	Total Solar Eclipse, 1901 May 18 (40 sec.)	F. W. Dyson
90	Comet <i>b</i> 1902 III. (Perrine), 1902 Sept. 29	Roy. Obs., Greenwich
91	Portion of Moon (Mare Serenitatis, &c.)	Yerkes Observatory
92	Portion of Moon (Rough Crater Region, Mare Nubium)	Yerkes Observatory
93	Portion of Moon (Tycho, Theophilus, &c.)	Yerkes Observatory
94	Portion of Moon (Bullialdus to Copernicus)	Yerkes Observatory
95	Portion of Moon (Copernicus)	Yerkes Observatory
96	Great Nebula in <i>Orion</i>	Yerkes Observatory
97	Great Nebula in <i>Orion</i> (Central portion)	Yerkes Observatory
98	Nebula in <i>Andromeda</i>	Yerkes Observatory
99	Nebula in <i>Cygnus</i> (N.G.C. 6960)	Yerkes Observatory
100	Nebula in <i>Cygnus</i> (N.G.C. 6992)	Yerkes Observatory
101	Cluster M 13 <i>Herculis</i> (N.G.C. 6205)	Yerkes Observatory
102	Cluster M 13 <i>Pegasi</i> (N.G.C. 7078)	Yerkes Observatory
103	Solar Surface with Faculæ	Yerkes Observatory
104	The Moon, 1900 April 5	P. Puiseux
105	The Moon, 1902 November 13	P. Puiseux
106	The Moon, 1903 February 6	P. Puiseux
107	The Moon, 1903 September 12	P. Puiseux
108	Nebulosity about 15 <i>Monocerotis</i>	E. E. Barnard
109	Milky Way† about β <i>Cygni</i>	E. E. Barnard
110	Nebulosity near α <i>Cygni</i>	E. E. Barnard

R.A.S. Ref. No.	Subject.	Photographed by
111	Milky Way near χ <i>Cygni</i>	E. E. Barnard
112	Star cloud in <i>Sagittarius</i>	E. E. Barnard
113	Milky Way in <i>Cepheus</i>	E. E. Barnard
114	Milky Way about M 8	E. E. Barnard
115	Milky Way about θ <i>Ophiuchi</i>	E. E. Barnard
116	Milky Way near N.G.C. 6475	E. E. Barnard
117	Great Nebula near ρ <i>Ophiuchi</i>	E. E. Barnard
118	Milky Way about 58 <i>Ophiuchi</i>	E. E. Barnard
119	Milky Way near <i>Omega</i> nebula	E. E. Barnard
120	Star cloud in <i>Sagittarius</i>	E. E. Barnard
121	Nebula about ν <i>Scorpii</i>	E. E. Barnard

Nos. 44-55 and Nos. 64 and 65 form a series of corona photographs, oriented and reduced to the same scale.

The above photographs are now on sale to Fellows as prints, either platinotype or aristotype, mounted on sunk cut-out mounts, measuring 12 inches by 10 inches, and also as lantern slides. Nos. 44-55 and Nos. 64 and 65 are also supplied as transparencies, $6\frac{1}{4}$ inches square.

Price of prints, 1s. 6d. each; lantern slides, 1s. each; packing and postage extra.

Unmounted prints, 1s. each, can be obtained to order.

Transparencies, $6\frac{1}{4}$ inches square (Nos. 44-55 and Nos. 64 and 65), 3s. 6d. each.

Orders to be addressed to W. H. Wesley, Burlington House, London, W. In ordering prints or slides the R.A.S. Reference No. only need be quoted, but in the case of prints it should be stated whether platinotypes or aristotypes are required.

The Gold Medal.

The Council have awarded the Society's Gold Medal to Professor Lewis Boss for his long-continued work on the positions and proper motions of Fundamental Stars. The President will lay before the Society the grounds upon which the award has been founded.

The Jackson-Gwilt Gift and Medal.

The Hannah Jackson (*née* Gwilt) Gift and Bronze Medal have been awarded to Mr. John Tebbutt for his important observations of Comets and Double Stars, and his long-continued services to astronomy, extending over forty years.

Publications of the Society.

During the past year vol. lxiv. of the *Monthly Notices* has been issued.

In accordance with the arrangement made with the Royal Society, mentioned in previous Annual Reports, four Appendices to vol. lxiv. have been issued.

The following volumes of the *Memoirs* have been published :—

Vol. liv. containing :

E. W. Brown, Theory of the Motion of the Moon.

W. Coleman, Measures of Double Stars.

Rev. W. Sidgreaves, Connexion between Solar Spots and Earth-magnetic Storms.

G. M. Seabroke [&c.], Measures of Double Stars at the Temple Observatory, Rugby.

W. H. Maw, Double-star Observations, 1899-1901.

R. T. A. Innes, Some Developments in Terms of the Mean Anomaly.

R. A. Sampson, Description of Adams's MSS. on the Perturbations of *Uranus*.

Vol. lv. containing :

Observations of Variable Stars made at the Rousdon Observatory under the direction of the late Sir C. E. Peek. Edited by H. H. Turner.

OBITUARY.

The Council regret that they have to record the loss by death of the following Fellows and Associate during the past year :—

Fellows :—William Anderson.

John Mackenzie Bacon.

Reginald Bushell.

Robert Prichard Davies.

Rev. Charles Evans.

William Francis.*

J. Horsley Haslam.

Rev. Andrew Henderson.

George E. Lumsden.

Frank McClean.

William Grant MacGregor.†

William Noble.

Sir Erasmus Ommanney.

William Montgomery Pierson.

Eyre Burton Powell.

Walter J. B. Richards.

Isaac Roberts.

Maurice Allen Smelt.

John Steele.

Sir Henry Thompson.

Associate :—Theodor Bredichin.

Obituary notices are also given of the following, who died in January 1905 :—

Edward Crossley.

Charles Horsley.

Paul Henry (Associate).

WILLIAM ANDERSON, the eldest son of Thomas Anderson, of Ballymena, co. Antrim, was born on the 7th of February 1870. He was educated at the Royal Academical Institution, Belfast, and on leaving entered the linen business. After a few years his health made it necessary for him to leave Ireland. He went to Madeira and afterwards to Jamaica, taking with him a 5-inch

* Obituary in *Annual Report*, 1904.

† Died in December 1903, but death not reported till 1904.

refractor by Grubb. He was elected a Fellow of the Royal Astronomical Society on the 10th of April 1896, and was also a member of the British Astronomical Association. He contributed to the *Monthly Notices* of April 1898 a paper on the "Zodiacal Light," and in the same year sent letters to the *Journal* of the British Astronomical Association and to the *Observatory* on the Zodiacal Light and Gegenschein. He also sent to the British Astronomical Association papers on sun-spots, on *Saturn's* rings, and drawings of *Jupiter*.

Mr. Anderson married in 1891 Margaret, daughter of Robert Christie, of Ballymena. He died in Jamaica on the 28th of March 1904, leaving a widow and one son.

THE REV. JOHN MACKENZIE BACON was born on the 19th of June 1846 at Lambourne, Woodlands, Berks. He was the son of the Rev. John Bacon and great-grandson of John Bacon, R.A., the sculptor. He studied at Trinity College, Cambridge, but failure in health obliged him to take an *Ægrotat* degree in 1870. He was ordained the same year, but never held a living or undertook other than temporary clerical duty.

Ill health compelled him to leave the tutorial work he had undertaken at Cambridge, and in 1876 he went to Coldash, Newbury, where he lived ever since, engaging in scientific studies and social schemes for the benefit of his poorer neighbours, founding local institutions of all kinds and spending his time freely in the service of others. Mr. Bacon was much interested in astronomy, and took part in three eclipse expeditions of the British Astronomical Association to Vadsö in 1896; to Buxar, India, in 1898; and to Wadesborough, North Carolina, in 1900—on the two latter occasions being director of the expedition.

He had long been fond of ballooning, and in 1898 he first embarked seriously on scientific *aëronautics*; since then he made many voyages, undertaking experiments in acoustics, meteorology, and kindred subjects. He met with many adventures, nearly losing his life in an attempt to observe from a balloon the *Leonid* meteor shower of November 1899. In November 1902 he crossed the Irish Channel in a balloon (the second time that this feat had been accomplished), and succeeded in taking a photograph of the sea bottom from a height of 600 feet.

He was the author of two works, *By Land and Sky* and *The Dominion of the Air*, besides many scientific and other papers in periodicals. He was also well known as a popular scientific lecturer.

He was elected a Fellow of the Society on the 10th of February 1888.

Mr. Bacon was twice married: first, in 1871, to Gertrude, daughter of the Rev. C. J. Myers; and secondly, in 1903, to Stella, daughter of Colonel T. B. H. Valintine, of Goodwood. He leaves three children. He died after a comparatively short illness on the 26th of December 1904.

REGINALD BUSHELL was born on 18th of August 1842 at Aigburth, near Liverpool. He was the second son of Mr. Christopher Bushell, a well-known member of the Liverpool Dock Board. Mr. Bushell was in business in Liverpool for many years, and was a member of the Mersey Docks and Harbour Board for seventeen years. He was a director of the Liverpool Overhead Railway and of the Sea Insurance Company. Mr. Bushell was interested in education, and was intimately connected with the Liverpool University from its foundation. He was a member of the Liverpool Council of Education and of other educational bodies in Lancashire and Cheshire, and was a justice of the peace for Cheshire. Mr. Bushell's scientific interests were meteorology and horology. He became, through his interest in clocks, an expert mechanician, and designed and executed several turret clocks which performed extremely well. In order to determine time he made himself a practised meridian observer. He was elected a Fellow of the Royal Astronomical Society on the 12th of May 1871.

Mr. Bushell died suddenly on the 11th of November 1904, at his residence at Hinderton Lodge, Neston, Cheshire, and leaves a widow, two sons, and one daughter.

EDWARD CROSSLEY was born in 1841. He was educated at private schools, and for a short time at Owens College, Manchester. In his sixteenth year he entered business in the firm of Messrs. John Crossley & Sons, carpet manufacturers, Halifax, the heads of which were his father and two uncles. He ceased to take an active share of the work of this firm when he was returned to Parliament for the Sowerby Division in 1885 to 1892. His Parliamentary work soon came to an end owing to indifferent health. Till his death he was chairman of the directors of the firm of John Crossley & Sons.

From boyhood he had a taste for astronomy, and, beginning with a 3-inch telescope, he went on to a 7-inch equatorial. In 1868 he built an observatory about 18 feet square, with a dome, in a space behind his house on the edge of the town. Here in 1869 Mr. J. Gledhill joined him. In 1872 Mr. Crossley built a house about two miles south of Halifax; and at the west side of the house the present observatory was built, with equatorial and meridian instruments. The equatorial was of 9-inch aperture by Cooke of York, and was fitted with driving clock, micrometers, and other apparatus. The meridian instrument was a $3\frac{1}{2}$ -inch transit circle by Cooke; in another room he had a small equatorial at one time, then a 7-inch equatorial, and afterwards a $4\frac{1}{2}$ -inch (new triple-glass) equatorial by Messrs. T. Cooke & Sons. With these instruments measures of double stars and observations of planetary phenomena, occultations of stars by the Moon, &c., were made. Mr. Crossley was also much interested in the measurement of base lines. He devised some ingenious measuring-rods, set up a measuring

bench, tested 1-foot, 3-foot, 40-inch, and 10-foot bars and rods. In 1884 he purchased the late Dr. Common's 3-foot reflecting telescope and built an observatory with an iron dome about 40 feet in diameter. After spending some years in improving the mechanical details of the instrument and trying to use it for celestial photography, he presented it to the Lick Observatory, the climate of Halifax being found quite unsuitable for so large an aperture. The 9-inch object-glass of the equatorial was sold a few years ago, and one of Cooke's new triple object glasses was put in its place. He was elected a Fellow of the Royal Astronomical Society on the 14th June 1867.

Mr. Crossley died suddenly on the 21st of January 1905.

THE REV. R. P. DAVIES was born in 1823 at Llanddulas, in Denbighshire, of which parish his father was then Rector. On his father's removal to Liverpool he received his early education at the Grammar School in that city. Thence he proceeded to Corpus Christi College, Cambridge, where he took his degree in 1845 as thirty-third Wrangler.

He was ordained to the curacy of Easington, in Yorkshire, in 1846. In 1849 he removed to Hertfordshire, becoming incumbent of the little church and district of St. Mary, in the parish of Hatfield. Here he remained for twenty years, and in 1869 he accepted from Sir T. S. Bazley, Bart., the living of Hatherop, in Gloucestershire, which he retained till his death thirty-five years afterwards.

He was much interested in astronomy, and was a careful observer. He became a Fellow of the Royal Astronomical Society on the 12th of March 1869. For some forty years he had an observatory with equatorial telescope and a good transit instrument.

For more than two years he was a regular contributor to the rainfall statistics of Mr. Symons.

He retained to the end of a long life interest in scientific pursuits, as well as care for the poor and the welfare of his parish and the neighbourhood.

JOHN HORSLEY HASLAM was born on the 25th of December 1850 at Baldhu Parsonage, Cornwall, of which place his father was Vicar. He went to St. Catharine's College, Cambridge; took his degree in 1874, and was ordained in 1874. For a short time he was curate of Wanstead, Essex; then took charge of the parish of Holbrook, Derbyshire; and in 1876 was appointed to St. John's, Highbury Vale. In 1880 he became Vicar of St. Matthias, Birmingham; in 1886 he was Rector of Gravesend, and in 1899 Vicar of St. Saviour's, Denmark Park.

He was earnest and energetic, an eloquent preacher, was skilful in painting, and had a great love for science, especially astronomy. He erected an observatory with his own hands in his garden at Wallington, Surrey, and afterwards at Gravesend

and Denmark Park, and was in much request as a lecturer. He was elected a Fellow of the Society on the 14th of March 1902.

In 1875 Mr. Haslam married Ellen Marianne, daughter of William Gorham, of Tonbridge. He had three children, two of whom survive him. Last year his strength began to fail, and he was advised to go to Switzerland ; while there an operation became necessary, but he had not strength to rally from it. He was buried at Lucerne, where he died on the 27th of August 1904.

ANDREW HENDERSON was born at Kirkwall on the 4th of January 1825. While still a child his parents removed to Dundee, where he was educated at Tay Square and Dundee Academies. In 1839 he entered the College of St. Andrews, of which Sir David Brewster was then Principal. Mr. Henderson was ordained in 1847, and became minister of the United Presbyterian Church at Coldingham, Berwickshire, till 1855, when he became minister of the United Presbyterian Church at Paisley, where he remained till his death, though in 1897 he had partially retired from active ministerial work.

In 1857 Henderson, with a few others, revived the Paisley Philosophical Society, of which he was President for eight years ; he was prominent in connexion with every educational institution in the town, especially the Paisley Technical College and the Paisley Grammar School. In 1888 he took a large share in building and equipping the Camphill School, then the largest elementary school in Scotland ; and only a fortnight before his death he visited the Technical College to inspect the new apparatus which had been supplied for the laboratories. He was at the head of the Committee of Management of the Astronomical Observatory founded by the late Thomas Coats, the instrumental equipment of which was entirely arranged by Dr. Henderson, who published in 1899 a small work, *The Coats Observatory: its History and Equipment*. His interest in astronomy led him to deliver numerous astronomical lectures in Paisley, while his energy and administrative ability made him a prominent member of nearly every educational board and committee of the charitable institutions of Dundee. In 1887 the University of St. Andrews conferred on him the degree of LL.D. He was elected a Fellow of the Royal Astronomical Society on the 9th of January 1885.

He died on the 29th of October 1904.

CHARLES HORSLEY was born on the 30th of May 1829 at Pye Bridge, Derbyshire, and educated at Derby Grammar School. After a few years spent at various engineering works he came to London and acted as agent and consulting engineer to Messrs. James Oakes & Co., of Alfreton, Derbyshire, a position he held until his death. He was elected a Member of the Institute of Civil Engineers in 1883, and was President of the Society of

Engineers in 1881. He invented a gas exhauster and also a patent syphon, which have since been extensively used.

In 1854 he married Louisa, daughter of Reuben Young, of Nottingham.

For many years he was an active member of the magisterial Bench for Middlesex, and in 1887 was one of the 60 chosen to carry on the work during the time that the Cities of London and Westminster were being amalgamated under the title of County of London. He was a member of the first London County Council, and was for 18 years Chairman of the East Islington Conservative Association.

Mr. Horsley was elected a Fellow of the Society on the 9th of April 1884. He died on the 4th of January 1905.

By the death of Mr. FRANK McCLEAN, LL.D., F.R.S., English astronomy loses not only an assiduous worker whose artistic sympathies ensured for all his work a high standard of elegance and finish, not only one whose enterprise carried his survey of the sky over both hemispheres, and whose insight detected for the first time direct evidence of the presence of oxygen outside our planet, but also one of those whose lavish generosity aided and inspired the work of many others. It would be difficult, perhaps impossible, to find his equal in the triple capacity of worker, discoverer, and benefactor.

The main facts of his life may be briefly told. He was born in 1837, the only son of the late distinguished engineer Mr. J. R. McClean, F.R.S., who was also a Fellow of our Society, and of whom the following words, of some significance in connexion with what we know of the son, are recorded in our annals: "His numerous acts of unostentatious kindness and generosity will make his loss deeply regretted by those—and they are many—who have been aided and befriended by him in their struggles and difficulties" (*Monthly Notices*, vol. xxxiv. p. 149). The son was educated at Westminster, at The College, Glasgow, and at Trinity College, Cambridge, of which he was a Scholar. He graduated as equal 27th Wrangler in 1859.* In the same year he took up his father's profession, and was apprenticed to Sir John Hawkshaw, and three years later he was taken into partnership in the firm of McClean & Stileman. In 1870, however, he retired from this work and devoted himself for the remainder of his life to scientific and artistic interests. He had married in 1865, and settled in 1871 at Tunbridge Wells (first at Ferncliffe and in 1884 at Rusthall House); and though latterly he also occupied a house in London (first at 21 Onslow

* The list is of some interest to astronomers. It contains among others the names of the Rev. J. M. Wilson, Senior Wrangler, now Archdeacon of Manchester (joint author with Mr. Gledhill of the book on double stars); the late E. J. Stone (4th Wrangler); Professor W. G. Adams (12th); Professor Alex. Herschel (20th).

Square and then at 1 Onslow Gardens), the greater part of his scientific work was done at Tunbridge Wells.

His first interests (in 1872) were not astronomical, being centred in electrical work on coils; but in 1875 an observatory was completed at Ferncliffe, and he began an examination of stellar spectra, devising a spectroscopic eyepiece for the purpose which was introduced to general notice by the late Mr. John Browning at one of the Royal Society's *soirées*, and has since become a well-established instrument. But his first published paper is dated some twelve years later than this, and shows that his thoughts had taken a new direction.

In 1889 he presented to the Royal Astronomical Society his "Photographs of the Red End of the Solar Spectrum," comprising just half the visible spectrum from λ 5800 to λ 7700, whereas Dr. Rowland's published photographs extended from λ 3900 to λ 5800. Alongside the photographs of the red end subsidiary photographs of the green to violet spectrum were given, so that there were exceptional facilities for determining the scale value. This thoroughness was characteristic of the work of Mr. McClean. Within a year he presented to the same Society parallel photographs of the spectra of the Sun, of iron, and of iridium; and within a few years other series of comparative pictures of high and low Sun spectra, and solar and metallic spectra. All these photographs were on a large scale, and afforded valuable information to those working at such spectra. The instrument employed at this time was a telescope stopped down to four inches aperture, of 98 inches focal length, fixed parallel to the polar axis, the sunlight being reflected into it by means of a heliostat mounted on the roof of Mr. McClean's house at Tunbridge Wells. From 1879 to 1890 a large Rutherford grating was used; in 1890 a Rowland plane grating was obtained and substituted. In taking the photographs of high and low Sun spectra particular attention was paid to two points: first, a method of screening different parts of the spectrum by means of glass cells an inch thick filled with coloured solutions; secondly, the special preparation of the photographic plates. All such work as this Mr. McClean undertook with his own hands. Some of the metallic spectra are those of rare metals not easily obtainable.

In 1895 Mr. McClean ordered from Sir H. Grubb a telescope of the pattern adopted for the Astrographic Chart, but with the addition of an objective prism with an angle of 20° ; and he commenced a systematic survey of the spectra of the stars brighter than $3\frac{1}{2}$ magnitude in the northern heavens. This work was completed in 1896; and in 1897 Mr. McClean carried the prism with him to the Cape of Good Hope and mounted it on the telescope at the Royal Observatory of the same pattern as his own. He thus extended his survey to the whole sky—a notable achievement for a man working single-handed. For this work he received the Gold Medal of the Royal Astronomical Society in 1899. From the survey he deduced important con-

clusions respecting the distribution of stars of different spectral types; and he discovered the presence of oxygen in the star β *Crucis* and other helium stars.

The main part of the northern survey is published in the Royal Society's *Philosophical Transactions*, vol. cxc. ; but the southern survey was published separately in a quarto volume of 16 pages and 30 plates, under the title *Spectra of Southern Stars*.

When Nova *Persei* appeared Mr. McClean, though a man of many interests and engagements, put all aside to devote himself to the spectrum of the new star, and obtained a valuable series of photographs, enlargements of which he presented to the Society. No reproductions of these were, however, published in our *Monthly Notices* along with the brief descriptions (see vol. lxi. pp. 334, 386), as is the case also with his earlier photographs of metallic spectra, &c. Perhaps the time has come when the rectification of this omission may be considered.

Quite independently of this work of a purely scientific kind, Mr. McClean has claims on the gratitude of astronomers for his munificent gifts and bequests to their science. In 1890 he founded at the University of Cambridge three Isaac Newton studentships for the encouragement of study and research in astronomy (especially gravitational astronomy) and physical optics at a cost of £12,500. To the Cape of Good Hope Observatory he presented the Victoria photographic telescope of 24 inches aperture and $22\frac{1}{2}$ feet focal length, with an 18-inch visual telescope associated, and fully equipped with both object-prism and slit-spectroscope.

These gifts have been supplemented by bequests at his death to the Universities of Cambridge and Birmingham, to the Royal Society, the Royal Astronomical Society, and the Royal Institution.

Some characteristics of the work of Mr. McClean, which have been already mentioned, may be emphasised. In the first place he always worked alone, never employing an assistant of any kind. It would have been easier for him than for most men to obtain such assistance; but the strength of his predilections may be gauged from the fact that when he was at the Cape Observatory, where Sir D. Gill would gladly have put at his disposal a part of the readily available resources of the Observatory, he preferred his solitary methods. He not only took all the original negatives himself, but made all the enlarged reproductions of the early work, for distribution. It was only in later years, and with obvious reluctance, that he yielded to pressure and enlisted the services of a firm of professional photographers to make these reproductions. This trait was no doubt allied to others which led him to make rare collections of old manuscripts and other beautiful things. It was probably unknown to many of his scientific friends that Mr. McClean was at heart not only a man of science but an artist, whose collections, bequeathed with characteristic generosity to the Fitzwilliam Museum at Cam-

bridge, are described as the most notable bequest made to it since its foundation. And as an artist he could not bear the touches of an alien hand to his work. Probably also his interest went deeper than with the majority of men, for in some of his benefactions also he spent much personal time and trouble in the settlement of the details. Thus, when he determined to present a large telescope to the Cape Observatory he spent many months in an attempt to devise an object-glass of a special kind, working out the numerical calculations himself, and also designed a special form of mounting. And although he was compelled ultimately to give up the object-glass, his ideas are incorporated in the mounting.

Of his originality no better proof could be offered than his discovery of oxygen in β *Crucis*. Such discoveries are sometimes so immediately confirmed by others that it almost seems a matter of chance who should be the first to make them ; but it was very different in this case. Even after the publication of full details it was many months before the announcement was received with anything but mistrust ; and in his address on presenting our Gold Medal to Mr. McClean in 1899 the President referred to this particular achievement in the most guarded language. A minor illustration of Mr. McClean's originality is afforded by his method of dividing the heavens for his survey according to galactic latitude and longitude (instead of according to the co-ordinates in vogue, which unnecessarily import terrestrial relations) ; a method which brings out at once several important features of distribution ; as, for instance, that the helium stars are mainly congregated in the two zones north and south of the galactic equator. Finally, a further reference may be made to one of his numerous benefactions—viz. the Isaac Newton Studentships, which aim at securing more *workers* for astronomy in this country as opposed to the provision of instruments to work with. That Mr. McClean was in full sympathy with the latter and more familiar form of benefaction he gave ample proof in other directions ; but this did not prevent him encouraging workers by a method which is unfortunately only too rare. We must go back a century and a half to find a similar encouragement ; for the Sheepshanks Scholarship at Cambridge is not only so small in amount as to have in itself little directive force, but differs from the Isaac Newton Studentships in being provided, as a memorial, by a number of persons. A better parallel to the studentships is to be found in the astronomical professorships at Oxford and Cambridge, founded in 1619 by Savile, in 1704 by Plume, and in 1749 by Lowndes. Since 1749 no noteworthy endowment of an astronomical career in this country has been made by an individual ; and, though Mr. McClean's endowment only makes provision for the outset of a career, its directive force has already been abundantly manifested.

Mr. McClean received the honorary degree of LL.D. from the

University of Glasgow in 1894. He was elected a Fellow of our Society in 1877, and of the Royal Society in 1895. He served on our Council almost continuously from 1891, but could never be persuaded to accept office, nor to serve on the Council of the Royal Society. He married in 1865 Ellen, daughter of Mr. John Greg, of Escowbeck, Lancaster, and leaves three sons and two daughters.

H. H. T.

WILLIAM GRANT MACGREGOR was born in 1838 in Strathspey, where a small branch of the clan had been long settled. In his sixteenth year he came to London, his parents apprenticing him to a commission merchant. He entered into business on his own account in 1877. In London he was attracted by Mr. Spurgeon's preaching, and for many years took an active part in the Sunday-schools, Bible classes, &c., connected with Mr. Spurgeon's Church, and was a trustee of the Stockwell Orphanage.

His interest in astronomy was derived from his kinsman Grant, the historian of astronomy, whom he assisted to translate Arago's *Popular Astronomy*. He was elected a Fellow of the Society on the 13th of May 1892. He was also a Fellow of the Royal Geographical Society, of the Royal Colonial Institute, and of several Scottish societies. He died on the 21st December 1903.

CAPTAIN WILLIAM NOBLE, the eldest son of William Noble, of Berwick-on-Tweed, was born in 1828. After being privately educated he entered the Army, from which he retired with the rank of captain. In 1851 he married Emily Charlotte, only child of Edward Irving, of H.M. 61st Regiment. After his retirement from the Army he settled at Forest Lodge, Maresfield, Sussex, giving a large part of his time to public duties. He was a justice of the peace for Sussex, Chairman of the Uckfield Bench, of the Uckfield Board of Guardians, and of the Rural District Council. He found in the execution of the duties attaching to these positions very congenial employment for which he was eminently fitted, possessing, as he did, a whole-hearted interest in the welfare of the district, a sturdy independence of character, and an active and business-like temperament.

Captain Noble set up an observatory at Maresfield with a good $4\frac{1}{2}$ -inch equatorial and other instruments. He was a constant and regular observer, and frequently contributed short notes to the *Monthly Notices* on occultations, drawings of sun-spots, &c. For nearly forty years he contributed each fortnight to the *English Mechanic* an article, over the signature "A Fellow of the Royal Astronomical Society," in which he criticised with some freedom current astronomical events. It must be admitted that he was not entirely free from prejudice, but the transparent honesty of his purpose gave value to these outspoken utterances. At the same time he took pains to answer the questions of interminable correspondents and inform them on astronomical and other subjects.

He was elected a Fellow of the Royal Astronomical Society on the 8th of June 1855, and has been a most constant attendant at the meetings. He frequently spoke, often contributing a shrewd observation and an amusing anecdote to the discussion. He served on the Council from 1866 to 1879, and with two short intervals from 1886 to 1904.

Captain Noble assisted in the foundation of the British Astronomical Association, and was chosen as its first President, the assistance and impetus he had given to amateur astronomy clearly marking him out for this post.

The humour and invariable cheerfulness of Captain Noble, combined with his deep interest in the welfare of the Royal Astronomical Society and of astronomy in general, made him very welcome and valuable both at the Council and the meetings of the Society.

Captain Noble died on the 9th of July 1904 after an illness of several months' duration. Mrs. Noble had died in 1899 after a married life of forty-eight years. One son survives him.

ADMIRAL SIR ERASMUS OMMANNEY, K.C.B., was born on the 22nd of May 1814. He entered the Navy at the age of twelve, and assisted at the landing of the British Army at Lisbon in 1827, and served as a midshipman on board the *Albion*, the flagship of his uncle, Sir John Acworth Ommanney, in the battle of Navarino. In 1835 he served as lieutenant with Captain (afterwards Sir James) Ross in an expedition to relieve whaling vessels ice-bound in Baffin's Bay. In 1840 he was appointed to the command of the steam sloop *Vesuvius*, and was actively employed in the Mediterranean for several years. In 1850 Captain Ommanney served as second in command under Captain Austin in an expedition sent by the Admiralty to discover the fate of Sir John Franklin. He travelled in sledges over five hundred miles, being away from his ship for sixty days, and discovered that Franklin and his companions had spent their first winter on Beechey Island. Shortly after his return to England the Crimean war broke out, and he was given command of the White Sea Squadron, which bombarded Archangel and other ports. He was promoted to be rear-admiral in 1864, when his active service with the fleet ceased. In 1875 he retired under the age limit.

Admiral Ommanney's most important scientific work was the geographical information he obtained in his Arctic explorations. He was one of the oldest members of the Royal Geographical Society. He was elected a Fellow of the Royal Society in 1868. He served on the Council of the British Association, and was treasurer in 1884 on the occasion of the visit to Canada. In 1885 an honorary LL.D. was conferred upon him by the University of Montreal.

Sir Erasmus Ommanney was one of the oldest Fellows of the Royal Astronomical Society, having been elected on the 14th of

January 1853. During his long connexion with the Society he had the good fortune to witness several of the most interesting astronomical phenomena of last century. In 1866 he observed the shower of *Leonid* meteors, and sent a brief description to the Society. He observed the transit of *Venus* at Luxor on the 12th of December 1874, Sir William Abney and Dr. Auwers being at the same station. A short account of an aurora borealis seen at Ilfracombe, given by him in the *Monthly Notices* for November 1870, is interesting from the remark: "During all my Arctic voyaging I never witnessed in any aurora the same conditions of varied colouring as were displayed on this occasion."

Admiral Ommanney died on the 21st of December 1904 at the residence of his son, St. Michael's Vicarage, Portsmouth.

WILLIAM MONTGOMERY PIERSON, of San Francisco, was a lawyer of prominence in California. He was born in 1842, and after receiving the ordinary education of the State schools was admitted to practise law before he attained his majority, a special Act of the State Legislature being passed expressly for the purpose. He became law partner of Henry H. Haight, afterwards Governor of California. Notwithstanding an active business life, he found time to devote to astronomy, and was well known on the Pacific coast as an excellent amateur astronomer. He took a prominent part in the formation of the Astronomical Society of the Pacific, and was chosen as Vice-President, succeeding Dr. Holden as President. Till his death he remained on the Board of Directors, the Finance and Comet Medal Committees. He fitted out at his own expense an expedition to observe the total solar eclipse in India in 1898. This expedition was directed by Professor Burckhalter, who used a rotating occulting plate to obtain an exposure of suitable length in different parts of the corona. In 1903 he presented his 8-inch reflector to the University of California. His loss was deeply felt by many American astronomers belonging to the Astronomical Society of the Pacific. He died in November 1904. Mr. Pierson was elected a Fellow of the Society on the 9th of January 1891.

EYRE BURTON POWELL, M.A., C.S.I., was for many years Director of Public Instruction in the Madras Presidency. He was one of the oldest Fellows of the Society, being elected on the 13th of January 1854. He had a small refractor in the grounds of the Government Native College at Madras, and frequently observed comets, double stars, &c., working in co-operation with Captain Jacob, the Hon. East India Company's Astronomer. His first contribution to the Society's publications is in 1854, when he communicated a series of observations of Comet II. of that year and a determination of its elements, and pointed out that these agreed with those of a comet observed in 1677 by Hevelius. In 1856 he forwarded to the Society his observations of 130 double stars made in the years 1853-4-5. These are published in vol.

xxv. of the *Memoirs*. As he had not a clockwork movement and his instrument was not a powerful one, he confined himself wholly to the observation of position-angles. From 1853-61 he made observations of the nebula round η *Argûs*, and of the variation in the brightness of η *Argûs* itself. Observations of double stars made by him at Madras in the years 1859-62 are given in vol. xxxii. of the *Memoirs*, and his observations of later date are to be found in *Monthly Notices* for November 1883. He also contributed several computations of the orbit of α *Centauri*, the first being in 1854 and the last in 1892.

Mr. Powell died at his residence at Streatham on the 10th of November 1904 at the age of 85 years.

DR. WALTER JOHN BRUCE RICHARDS was a distinguished priest of the Roman Catholic Church and an intimate friend of Cardinal Manning and Cardinal Vaughan. Born in 1835, he was ordained priest in 1859, and was in 1870 appointed by Cardinal Manning Diocesan Inspector of Schools. The main work of his life was educational, and his duties brought him into frequent contact with educationalists outside his own communion. He was chosen to serve on a Royal Commission on Poor Laws and Industrial Schools.

Dr. Richards's interest in astronomy was especially in the field of selenography. He was one of the original members of the Selenographical Society and a contributor to its *Journal*, which was issued from 1878 to 1882. The *Journal* was discontinued, and the Society practically came to an end when Mr. Neison (Nevill) left England for Natal. Dr. Richards also contributed monthly articles on lunar work to the *Astronomical Register* from 1881 to 1883, containing notes on lunar formations and suggestions for observation.

He was elected a Fellow of the Royal Astronomical Society on the 11th of February 1876. He died in September 1904.

ISAAC ROBERTS was born at Groes, near Denbigh, North Wales, on the 27th of January 1829; before his childhood was over, however, the family removed to Liverpool, and in that city the greater part of his long life was spent. His parents were not well to do, his father being a farmer, and later a bookkeeper; and after receiving an elementary education he was set to work in the building trade: in this he prospered greatly, becoming ultimately a partner in a large firm of contractors, with ample means for the prosecution of his scientific researches.

His taste for these was shown in early days when as a builder's apprentice he attended evening courses on scientific subjects; but he had entered his fiftieth year before his first astronomical telescope was mounted. This was a 7-inch refractor, and was followed by a reflector of 20 inches aperture and 98 inches focal length for photographic purposes: the two telescopes were mounted on the same declination axis and were moved

together in R.A. by the same clock, but had independent movements in declination. With this arrangement the whole of Dr. Roberts's work in celestial photography was done, first at Maghull, near Liverpool, and since 1890 at Crowborough, in Sussex. He spent much labour in devising an instrument for copying the images of stars from the photographic film and engraving them on a copper plate: an account of this instrument, which was called a pantograver, will be found in *Monthly Notices*, vol. xlix.

Dr. Roberts's first programme of astronomical research was the formation of a photographic chart of the northern heavens. This work was actually commenced, but was abandoned when the scheme for an international astrographic chart was approved. After this he applied himself to the photography of star clusters and nebulae, achieving a most remarkable success and adding greatly to our knowledge of these objects. In 1893 he issued a volume of reproductions of photographs of stars and nebulae, and this was followed by a second collection six years later.

He became a Fellow of the Royal Astronomical Society in 1882 and of the Royal Society in 1890. In 1892 the degree of D.Sc. was conferred on him by Dublin University, and in 1895 he received the gold medal of the Royal Astronomical Society for his photographs of star-clusters and nebulae.

The President, in presenting the medal, said:

"Turning to the absolute work that the Medallist has carried out, it should be stated that he commenced photographing the stars with various photographic lenses in 1883. The paper in which he recounted what he had done is found in *Monthly Notices* of January 1886. Each year since then he has contributed to the *Monthly Notices* papers on the subject of the research which he undertook, interspersed with others bearing upon stellar photography. In December 1886 he produced a photograph of the nebula in *Orion* with his 20-inch reflector, with an exposure of 15 minutes; and almost exactly two years after he produced a photograph of the same object with an exposure of 81 minutes, and introduced us to nebulosities in the surrounding parts which were unsuspected before. Other photographs of the same object, with more prolonged exposure, can be also remembered. A little afterwards he produced his recently published photograph of the great nebula in *Andromeda*, giving an exposure of four hours to the plate. In this prolonged exposure we have an example of a triumph of patience and of instrumental perfection."

The end came with tragic suddenness. On Sunday, 17th of July 1904, after a walk in his garden, he complained of a compression in the chest, and passed away in less than an hour.

Dr. Roberts was twice married: his second wife, *née* Miss Dorothea Klumpke, who survives him, is herself an able worker in the field of astronomical research.

Although he did not take a prominent public part in politics, he was a zealous Liberal and greatly interested in education,

being a vigorous opponent of the recent Education Acts. Under the terms of his will large bequests are made to Liverpool University and the University Colleges of North and South Wales.

MAURICE ALLEN SMELT was born in 1821. He went to Gonville and Caius College, Cambridge, and took his degree in 1842. He was ordained deacon in 1843, and after holding curacies in Kent and Hampshire was appointed Rector of Medstead, Hants, from 1863-67. He retired to Cheltenham, and gave ready assistance to religious and philanthropic societies. In particular he was for twenty years honorary secretary to the Cheltenham and Gloucester Society for the Care of the Blind. He took an interest in several branches of science, especially astronomy and meteorology. He became a Fellow of the Royal Astronomical Society on the 8th of March 1861.

Mr. Smelt died on the 6th of December 1904 at the age of 84 years.

CAPTAIN JOHN STEELE was born in 1819. He went to sea in 1834, and served a somewhat rough apprenticeship in the merchant service. He remained at sea for thirty-eight years, during thirty-three of which he was in command, most of the time in sailing ships. He was employed in transport service at Balaclava during the Crimean war, and after that time made frequent journeys to China and Japan. In 1872 he was appointed Nautical Assessor to the Board of Trade, and in 1878 Examiner in Seamanship and Secretary to the Local Marine Board, a post he held till 1897. He was one of the founders of H.M.S. *Worcester* Nautical School, and was a member of its committee till his death. Captain Steele throughout his whole life used his influence consistently towards improving the condition and tone of the merchant service. Captain Steele was a Fellow of the Royal Meteorological Society and for twenty-eight years kept records at sea for that Society. He became a Fellow of the Royal Astronomical Society on the 13th of February 1880. He frequently attended and occasionally spoke at the meetings, but did not contribute to the publications of the Society.

Captain Steele married twice. He died on the 19th of April 1904, and leaves a widow and a daughter.

SIR HENRY THOMPSON was born at Framlingham, in Suffolk, on the 6th of August 1820. In accordance with his father's wishes, though contrary to his own, he was engaged till he was twenty-seven years old in commercial pursuits. In the year 1848 he entered University College Hospital, where his surgical skill and deep interest in his profession were immediately conspicuous. In 1853 he was appointed Assistant-Surgeon to the hospital, and in 1866 Professor of Clinical Surgery. His reputation as a skilful surgeon was so great that in 1863 he was consulted by

the King of the Belgians, when his accurate diagnosis and successful operation brought him professional renown. Along with a large practice and his duties at University College, Sir Henry Thompson found time to develop his marked talent for art and literature. He studied painting under Elmore and Alma-Tadema, and frequently his pictures were exhibited at the Academy or the Paris Salon. He wrote several novels, the first, *Charley Kingston's Aunt*, had no fewer than fifteen editions. His professional writings were numerous, and mention may be made of some which are of general interest. His article in the *Quarterly* thirty years ago advocating Cremation led to its adoption in England; and Sir Henry Thompson was President of the Cremation Society till his death. His books *On Food and Feeding* and *Diet in Relation to Age and Activity* went through many editions. At the age of eighty he became an enthusiastic automobilist, and in 1902 wrote a small book on the motor car.

Sir Henry Thompson's interest in astronomy led him to build an observatory at his country house at Molesey. Messrs. Cooke erected for him in 1887 an equatorial with a visual object glass of 12 inches and a photographic object glass of 8 inches aperture. With a grating spectroscope attached to this equatorial he and his assistant, Mr. A. Taylor, made observations of widened lines and other solar phenomena. Some observations of bright line spectra and spectra of nebulae made at the Observatory were communicated to the Society by Mr. Taylor in January 1889. In 1891 Sir Henry Thompson presented to the Royal Observatory his 8-inch photographic telescope, which has since been in regular use for photographs of the Sun, and has on several occasions been used in eclipse expeditions as a coronagraph. In 1896 he made to the Royal Observatory the munificent gift of a large equatorial with a 26-inch photographic refractor at one end of the declination axis and a 30-inch reflector at the other. He was elected a Fellow of the Society on the 11th of May 1888.

Sir Henry Thompson married in 1851 Miss Kate Loder, the distinguished pianist. He leaves one son and two daughters.

THEODOR ALEXANDROVITCH BREDICHIN was born in 1831 at Nikolaieff, Russia, and was educated at Odessa and the University of Moscow. In 1857 he was appointed to the staff of the Moscow Observatory, and almost at once commenced the series of investigations, by which he will be chiefly remembered, on the dynamical theory of cometary appendages. His earliest papers on the subject were written in Russian, and it was from the short accounts of the work which he from time to time contributed to the *Astronomische Nachrichten* that it first became generally known to astronomers outside his own country. In 1865 he was promoted to the directorate of the Observatory, and from 1875 to 1890 a number of extensive memoirs appeared in the *Annales de l'Observatoire de Moscou*, in which the theory was fully developed. In the latter year he became Director of

the Pulkowa Observatory, in succession to Otto Struve—a position from which he retired in a few years—and a member of the St. Petersburg Academy. Most of his subsequent papers have been published in the *Bulletin* of the Academy. A systematic exposition of Bredichin's work on comets has been written by R. Jaegermann. Many of his other papers refer to meteors, meteor streams, and stationary radiants. In 1884 he was elected an Associate of the Royal Astronomical Society.

His death occurred, after a short illness, on the 14th of May 1904.

PAUL HENRY was born at Nancy on the 21st of August 1848, and died at Paris on the 4th of January 1905. His younger brother Prosper, in collaboration with whom all his astronomical work was done, died on the 25th of July 1903. In the Report of the Council for last year an account is given of the work of the brothers Henry, and it was stated that it was not possible to separate the work of Prosper Henry from that of his brother Paul. A more detailed notice of the work of MM. Henry will be found in that report. Appointed Assistant Astronomers at the Paris Observatory in 1868, they set themselves to complete Chacornac's Charts of the Ecliptic. As they approached the Milky Way the large number of stars made visual observation almost impossible, and they tried photography. The results they obtained, presented by Admiral Mouchez to the Academy in August 1884, were so satisfactory that they commenced the construction of a 12·8-inch photographic object-glass. This realised all their expectations, and they found that a field of 3° in diameter was sharply covered, and that with an hour's exposure stars of the 14th and 15th magnitudes were shown. In the course of a few years the international photographic chart of the heavens was commenced with instruments of the pattern first constructed by MM. Henry.

M. Paul Henry was a Chevalier of the Legion of Honour and Officer of Public Instruction. He was elected an Associate of the Royal Astronomical Society on the 8th of November 1899.

PROCEEDINGS OF OBSERVATORIES.

*Royal Observatory, Greenwich.**(Director, Sir William Christie, K.C.B., Astronomer-Royal.)*

Transit Circle.—During the year 13,549 observations of transits and 12,309 of meridian zenith distances were obtained. These include about 8400 observations of stars within 26° of the pole, leaving about 5000 observations to be obtained this year to complete five observations of each star in the Catalogue. The Sun has been observed 163 times and the Moon 89 times. Reflexion observations of stars have been obtained on 105 nights.

The re-reduction of Groombridge's observations is completed. The ledgers of the original observations are printed, and the Catalogue as far as 18^h. Proper motions of the stars have been derived by comparison with modern Greenwich observations, and a comparison for check made with the Radcliffe (1845.0) Catalogue and the catalogues of the *Astronomische Gesellschaft*.

Mr. Cowell's analysis of the Greenwich lunar observations 1750–1901 is completed as far as the longitudes are concerned, and coefficients for 145 terms have been deduced from the observations as compared with revised theory. A comparison with the theoretical calculations of Professor Brown, Mr. Radau, and Dr. G. W. Hill shows an agreement to well within $0''.10$ for the large majority of these terms.

The Altazimuth.—With this instrument, used as a reversible transit circle, 1310 observations of right ascension and 1274 of north polar distance have been obtained. The instrument has been used in all four positions in the meridian for observation of the Sun, Moon, and planets and the fundamental stars contained in Newcomb's Catalogue. Since the beginning of 1905 observations of the crater Mösting A, as well as of the limbs of the Moon, have been obtained in the second and third quarters. The observations of transits will serve to connect the observations of the first and second limbs made before and after full respectively; and the observations of zenith distance will, in co-operation with the Cape Observatory, serve to determine the parallax of the Moon. A series of reflexion and direct observations of zenith distance have been obtained in the four positions in the meridian. Extra-

meridian observations of the Moon have been obtained throughout the first and last quarters, when the Moon cannot be observed on the meridian or would be observed in a bright sky. The total number of extra-meridian observations obtained of the Moon is 63—35 near the beginning and 28 near the end of the lunation.

Reflex Zenith Tube.—During the year 817 double observations and 70 single were secured. Observations of the brighter stars have been made over as long periods as possible. γ *Draconis* has been observed 78 times, β *Draconis* 44 times, ϵ *Cygni* 41 times, and θ *Ursæ Majoris* 29 times.

Equatorials.—A hundred and nine observations of occultations of stars by the Moon have been made. These consist of observations by one or more observers of forty-six phenomena of disappearance or re-appearance.

28-inch Refractor.—The weather has been even more unfavourable than in 1903 for the observation of close and difficult double-stars, as may be seen from the following statement of the year's work :—

Month.	No. of Nights on which Observations were made.	No. of Good Nights.	No. of Stars Ob- served.	Month.	No. of Nights on which Observations were made.	No. of Good Nights.	No. of Stars Ob- served.
Jan	8	0	36	July	15	5	163
Feb.	10	1	54	Aug.	12	2	116
Mar.	11	2	80	Sept.	9	2	74
Apr.	10	4	120	Oct.	8	0	69
May	11	3	71	Nov.	7	1	73
June	10	5	107	Dec.	5	1	69
Totals for year					116	26	1032

An analysis of the observations gives :

76 stars of distance	$< 0''.5$
85 " "	$0''.5-1''.0$
127 " "	$1''.0-2''.0$
372 " "	$> 2''.0$

Amongst the stars observed are *Sirius* (once), *Procyon* (3 nights), κ *Pegasi* (7 nights), and δ *Equulei* (11 nights).

Thompson Equatorial.—With the 26-inch refractor 59 photographs of *Neptune* and satellite have been obtained on 28 nights, of which 41, belonging to the opposition 1903-4, have been measured. With the 30-inch reflector 178 photographs (generally four exposures on each) of 60 minor planets have been obtained. Comet α , 1904 (Brooks), was photographed on 58 nights, 76 photographs, each with several exposures, being obtained. Encke's Comet was attempted on several nights, but owing to unfavourable weather only one successful photograph was obtained. A few photographs of nebulae were also taken.

Astrographic Equatorial.—During the year 200 photographs were taken on 86 nights. These include 103 successful chart plates more suitable for reproduction than those already obtained, 16 catalogue plates, 8 photographs of suspected variables, and 55 plates rejected mainly owing to photographic defects in the plates or to their not reaching the required standard in showing faint stars. During the year 108 plates have been measured, and the measurement has now been carried to within 3° of the pole. The number of plates left to be measured is 28. Vol. i. of the *Astrographic Catalogue*, containing the measures from Dec. 64° – 72° , was published in the spring. The printing of Vol. ii. is being carried on continuously, Zones 72° , 73° , and 74° to 12^h having passed through the press. The counting of the stars on the chart plates has been continued from Dec. 71° to Dec. 73° .

The publication of the Greenwich section of the *Astrographic Chart* by means of enlarged photographic prints was commenced at the beginning of May, the three Zones 65° , 66° , and 67° (232 plates) being taken in hand. Up to the middle of December the enlarged prints from 116 plates (12^h to 24^h) had been distributed to about fifty observatories and other institutions. It is expected that the publication for these three Zones will be completed in about twelve months from the time of commencement, after which the work will be continued with Zones 68° , 69° , and 70° .

Measures of Eros Photographs.—Besides *Eros*, ten or twelve reference stars taken from M. Loewy's list within $50'$ of the centre of each plate and distributed as symmetrically as possible with respect to the planet, and six comparison stars of about the same magnitude as *Eros* and within $25'$ of the centre, have been measured on each of the 198 plates taken with the astrographic equatorial. *Eros* and six comparison stars have been measured on each of the 152 plates taken with the Thompson Equatorial. Generally four exposures were measured on each plate in both the direct and reversed positions. The means of the separate measures and exposures have been taken and examined. Plate constants have been determined for about half the astrographic plates. A preliminary discussion of 27 photographs obtained on October 26 and October 27 has been made, and is published in the *Monthly Notices*, vol. lxiv. p. 626.

Photoheliograph.—Photographs of the Sun have been taken during the year 1904 on 230 days, and 541 of them have been selected for preservation. These were all taken with the Thompson Photoheliograph mounted upon the 26-inch photographic refractor. Upon three of these days photographs were also taken with the Dallmeyer Photoheliograph. Photographs have been received from India up to 1904 November 10; and there are now photographs available for the year ending on that date for 352 days out of 366. No photographs have been received from Mauritius since 1903 December 31, but the arrival of photographs for the first six months of 1904 is expected

shortly. The measurement of the Greenwich photographs had by the end of the year been carried as far as 1904 December 12, and of the Indian ones as far as 1904 October 11, and the reductions are in a very forward state. In the matter of printing, the complete proofs of the results for 1903 have been received from the printer.

The increase of solar activity during the year 1904 has been steady but not rapid, and there have been no groups of spots of at all unusual dimensions.

Observations of Meteors.—The *Perseid* meteors were well observed on four nights, the number of meteors between August 10 and 14 being 473. A fair number of *Leonids* were observed on the morning of November 15, 342 meteors being seen during the night. A summary of the observations of *Leonids* is given in *Monthly Notices*, vol. lxxv. p. 154.

Longitude Observations.—The printing of the determination of the longitude Greenwich-Waterville-Canso-Montreal is finished, and copy is being prepared for the printers of the determination Paris-Greenwich made in 1902. A short notice of this determination is given in *Monthly Notices*, vol. lxxv. p. 219.

Mr. Crommelin and Mr. Bryant have been appointed assistants on the new establishment, and Mr. Davidson has been promoted to the higher grade of Established Computer.

Royal Observatory, Cape of Good Hope.
(*Director, Sir David Gill, K.C.B., H.M. Astronomer.*)

By the death of Mr. Frank McClean the Observatory has lost a most sympathetic and generous patron, whose benefactions to the establishment are too well known to need mention here.

His genuine devotion to his work, coupled with his many acts of personal kindness, has endeared him to all with whom he came in contact during his stay at the Cape in 1897, and his loss is felt by every member of the staff as that of a true and warm-hearted friend.

A very large amount of labour has been devoted during the year to work connected with the installation and determination of constants of the new transit circle.

The investigation of the errors of division for every division line on the fixed circle ($5'$ to $5'$) has been completed, and for the movable circle the error of each line marking the degrees. The observations were begun on 1903 September 28 and completed 1904 October 24: ten different observers took part in the work. The investigation involved 76,524 pointings for the fixed circle and 22,320 for the movable circle.

Four complete and independent series of investigations of pivot error were made during 1904: two clamp E and two

clamp W. All the series agree with each other and with the results obtained in 1903.

Investigation of the flexure and torsion of the axis, flexure of the tube and circles, constancy of the nadir under opposite conditions of motion from the zenith, have also been made, as well as a determination of the screw errors, screw value, and contact intervals of the Repsold travelling wire micrometer.

These operations were carried on day and night, to the practical exclusion of ordinary meridian observing with the new transit circle, because it is only by such investigations and their immediate discussion that instrumental defects can be discovered and remedied and a sound observing system with a sound instrument established.

The object-glasses of the long-focus lenses for adjusting the upper marks vertically over the underground marks have now all been received from Mr. Simms, and are in process of being mounted.

The observers have all passed through a course of training in observing by the Repsold method with the travelling wire—that is to say, in the original method proposed by Dr. Repsold in which no clockwork is employed to aid the observer. The apparatus for the automatic motion of the travelling wire at approximately the apparent rate of the star's motion across the field is under construction by the Société Genevoise.

A large number of observations have also been made to test whether the travelling wire method is free from the personal error in right ascension depending on magnitude. The result goes to show that by the travelling wire this source of systematic error is almost, if not entirely, eliminated. The actual mean for the six observers makes a fainter star observed later than a bright star by $0^s.0026$ per magnitude, or about one-sixth part of the corresponding personality for the same observers when employing the usual method of chronograph observing. The mean result, however, scarcely exceeds its probable error, and it seems likely that with more experience of the method an almost complete elimination of personal error will result, not only in personality depending on magnitude, but also independent of the velocity and direction of motion of the star.

The new transit circle will be brought into regular catalogue observing work from the beginning of 1905.

Some experimental alterations were made on the new sidereal clock, after which its performance has been so far satisfactory—the variations of daily rate during its last period of trial not exceeding $\pm 0^s.03$. This, however, does not represent the accuracy of rate which should be attainable; indeed, the variations show a dependence on the difference between the temperatures at the top and bottom of the pendulum. The pressure of the air is maintained constant at 33 mm. within ± 0.1 mm., and the temperature of the water that circulates about the inner iron case is also maintained constant within ± 0.1 F. But the

constant temperature selected for balancing the electric bridge that regulates the temperature (85° F.) has proved unnecessarily high—viz. 10° above that of the maximum temperature of the present room.

The result has been that the temperature of the air inside the iron clock-case, in consequence of radiation from the outer case (although the space between the water tubes and the outer case has a 2-inch-thick lining of felt) is always lower than that of the circulating water, and there are variable differences between the readings of the thermometers near the upper and lower ends of the pendulum which would account for errors of $0^{\circ}\cdot 02$ or $0^{\circ}\cdot 03$ in daily rate.

An outer chamber 8 feet square inclosing the clock case and having double wooden walls, 9 inches apart, the space between the walls being filled with sawdust, is now being constructed. The temperature of the air in this chamber will be automatically maintained at 74° F., and thus it is believed that a nearly perfect identity of temperature will be maintained throughout all parts of the inner clock-case.

Owing to an unfortunate accident which occurred during the absence of the regular observers the driving worm and sector of the Victoria telescope were damaged, and the moving portion of the instrument, including the polar axis and telescope tubes, had to be raised in order to remove the damaged sector. The sector, driving worm, and slow-motion gear have been sent to Sir Howard Grubb for alteration and repair.

The instrument was in consequence only in use till August 26, and was employed principally for the photography of star-spectra for determination of motions in the line of sight. Seventy-four star spectra were photographed during this period, of which thirty have been measured and radial velocities deduced for *a Phœnicis*, *a Tauri*, *a Argûs*, *a Canis Majoris*, *a Canis Minoris*, *β Geminorum*, *a Boötis*, and *α₂ Centauri*.

The progress of printing the Cape Catalogue of 8560 stars (Photographic Zone Standards) has been provokingly slow. The copy for press was sent off on 1902 August 6: only 112 pages of proof were received during the year.

The catalogue of 4360 stars, including 2798 selected zodiacal stars and all stars brighter than $8\cdot 1$ magnitude which are not contained in Gould's General Catalogue (excepting those in the zone decl. -40° to -52° , most of which are included in the Cape Catalogue for 1900), is nearly completed in manuscript.

Part I. vol. xi. of the *Cape Annals*, containing a discussion of the Heliumeter Triangulation of Southern Circumpolar Stars within 2° of the South Pole, has been distributed.

Part II. of the same volume, containing the results of a discussion of photographic plates covering the same region, has been passed through the press.

The work of the old transit circle has been confined to the few observations necessary to complete the catalogue of 2798

selected zodiacal stars, and to a re-determination of the personal equation of the observers depending on magnitude, besides the necessary determinations of time. The total number of observations is therefore much less than usual.

Number of transits ...	3658	Azimuth	81
Determinations of Z.D.	150	Run	63
Collimation	59	Nadir	62
Level	89	Flexure... ..	2

All observations are reduced to the end of December 1905.

With the new transit circle, in addition to a large amount of observations for practice in the "moving wire" method of observation, 1081 transits have been observed (twenty contacts each) for determination of personal equation depending on magnitude.

Only fifteen separate phenomena of occultations have been observed during the year—viz.:

Disappearances at the dark limb	10
Reappearances " " " " "	5

An announcement of the discovery of a new comet by M. Borrelly at Marseilles was received on December 31, and an observation was secured the same evening.

Helimeter.—Of the major planets, 145 oppositions on 19 nights have been observed with the heliometer during the year, and 841 observations in connection with the triangulations of the comparison stars in this and other oppositions.

The triangulations of the comparison stars for *Mars*, 1901, *Mars*, 1903, and *Jupiter*, 1903, are now completed.

Thirty-three observations have also been made connecting the distances of the stars employed as standards in Cookson's observations of *α Centauri* in 1901 and 1902 with pairs of stars contained in the South Polar area.

The instrumental distances have been computed and checked for the following triangulations:—

Uranus, 1898, 1899, 1900; *Saturn*, 1898; *Jupiter*, 1898, 1899, 1900; *Neptune*, 1897-1904.

Those for *Uranus*, 1901-1904; *Mars*, 1901 and 1903, have been partially reduced.

Astrographic Equatorial.—With this instrument 548 plates have been taken during the year. Of these, 116 Chart plates with triple exposures of 20^m, 236 Catalogue plates, 35 of *Jupiter's* satellites, 28 miscellaneous plates for Mr. Franklin-Adams, and 15 adjustment plates are passed as satisfactory. There still remain to be taken 83 Chart plates with triple images, 151 Chart plates with single images, and 193 of the second series of Catalogue plates; 3 triple-image Chart plates and 24 Catalogue plates taken before 1904 have been rejected during 1904.

The grain of the Ilford Monarch plates was found to be too coarse for the most accurate measurement of images on the Catalogue plates, and on July 21 return was made to the Ilford Rapid plates.

During the year 1904, 183 Catalogue plates, containing 117,073 stars, have been measured in reversed positions of each plate—including 2157 standard stars, each of the latter being measured in reversed positions of the plate by both the measurers employed on each plate. Eleven plates measured in former years have since been rejected. The actual state of the work is as follows :—

No. of Plates Measured.			No. of Plates Copied for Press.		
Before 1904.	During 1904.	Out- standing.	Before 1904.	During 1904.	Out- standing.
577	183	752	302	108	1112

The total number of measured plates is now 760, containing over 440,000 stars.

Telegraphic signals were exchanged with Major O'Shee, R.A., of the Anglo-Portuguese Boundary Commission, on April 22, 26, and 28. The observations were reduced at the Cape, and the resulting longitude of the observing pillar at Tete—viz. $2^h 14^m 21^s.04$ —has been communicated to the Colonial Office.

Major Watherston, R.E., C.M.G., arrived at the Observatory on November 22, and during his stay until December 14 practised observing with the 14-inch altazimuth, and, as a first step in the determination of the longitude of Accra, on the West Coast of Africa, made with Mr. Pett a very satisfactory determination of his personal equation in time determination and in sending and receiving submarine mirror signals.

The records of the seismograph have been regularly forwarded to Professor Milne, Secretary to the Seismological Committee of the British Association.

The meteorological observations made during 1903 have been communicated to the Cape Meteorological Commission.

H.M. Astronomer was absent on leave from March 26 to October 25. During his visit to England he attended the Congress of the International Association of Scientific Academies as a delegate of the Royal Society, and was also much occupied with preliminary arrangements in connexion with the approaching visit of the British Association to South Africa in August 1905.

*Geodetic Survey of South Africa.
(Report from Sir David Gill.)*

The work of the Geodetic Survey in the Transvaal and Orange River Colony has been energetically pushed on under Colonel Morris.

The whole of the reconnaissance of the principal chains of triangulation, about 2200 miles in length, has been completed,

with the exception of 360 miles, which have been discarded as not absolutely necessary.

The beaconing of all points, 125 in number, of the primary chains has been completed, leaving only 47 points of a secondary chain from Ottoshoop to Kimberley to be beaconed. The base lines at Kroonstad and Houts River (some thirty miles north of Pietersburg) have been measured.

The angles of the whole chain from Newcastle in Natal through Belfast to Ottoshoop (435 miles in length, containing 38 points, including four base terminals) have been measured.

The angles of another chain from Pretoria southwards through Basutoland to Cala in the Cape Colony have reached the neighbourhood of Lindley in the Orange River Colony: the work done covers 160 miles of chain, containing 16 points, including two base terminals.

Levelling operations from M. S. L. at Lorenzo Marques have been carried along the railway to Melalane (86 miles); the levelling of the remainder of this line (107 miles) to Machadodorp has been left for execution next winter. From Machadodorp the chain of levelling has been carried a further 136 miles—that is, within twenty miles of Pretoria. The total amount of levelling done is thus 222 miles during five months of 1904.

Observations for astronomical latitude and azimuth have been made at Belfast (S. terminal of base), Ottoshoop (N. terminal of base), and Observatory Hill (Johannesburg); and observations for astronomical latitude only at

N. terminal of base	}	Points on the Belfast base extension.
Langekloof		
Mare's Kop		
Inkwelo	}	In the north of Natal.
Salt Lake		

The whole of the above astronomical observations, with the exception of the latitudes of the two points in Natal, have been reduced; the horizontal and vertical angles of the chain Newcastle-Belfast and Belfast-Ottoshoop have also been reduced and the geographical co-ordinates computed.

The results of the base measurements made, like those mentioned in last report, with nickel-steel wires are most satisfactory. The lengths of the wires were determined before and after the measurement of each section by comparison with a 480-foot ground base, the length of which was similarly measured with the bars of the geodetic base apparatus before and after the measurement of each section of the base.

The results were :—

	Mètres.	Mètre.	No of Sections.
For the Kroonstad base	19787'341	±0'004	4
„ „ Houts River base	33961'340	0'005	8

These probable errors of the total length of the base are derived from the differences of the three independent measures of each section, and include therefore all the effects of the accidental errors of measurement with the Jäderin wires as well as the accidental errors of the different measurements of the standard base, but not the systematic errors due to the determination of the absolute length of the steel bars of the geodetic base apparatus.

The accuracy attainable with the Jäderin method and the employment of *invar* wires is thus all that can be desired.

Up to the present time the computations include the closure of fifty-seven triangles. The errors range as follows :—

		0"0	0"5	1"0	1"5	2"0
		to	to	to	to	to
		0.5	1.0	1.5	2.0	2.5
Newcastle-Belfast ...	...	10	4	3	0	1
Neighbourhood of Belfast...		8	5	4	1	2
Belfast to Ottoshoop	...	13	4	1	0	1
		31	13	8	1	4

The probable error of the levelling operations appears to be about 1 inch per 100 miles.

The difference between the length of the side (Salt Lake-Inkwelo) in the north of Natal, as found on the one hand from the Natal base and on the other from the Belfast base, is 1.46 foot in 30.7 miles, or about 1 : 100,000 ; an agreement which appears to indicate that these two independent systems of triangulation—the one depending on short base lines measured with the steel bars and the other on long base lines measured with nickel steel wires—are in substantial agreement.

As mentioned in last report, progress with the arc of meridian, north of the Zambesi, had been very much hindered by grass fires, and any but astronomical observations for latitude at Msambamsou and for latitude and azimuth at Kawira had been impossible. Dr. Rubin was in consequence instructed to demarcate the Portuguese boundary running due south from the Zambesi near Zumbo, and to fix the point where the 15th parallel of latitude crosses the river Loangwa. This work, together with that of reconnaissance and beaconing, occupied Dr. Rubin and his party till April 1904, since which time the points Tondongwe, Inyangan, and Msambamsou have been occupied for the measurement of horizontal and vertical angles and astronomical latitude determined at Kapsuka. No report of work after June 30 has yet been received from Dr. Rubin.

Royal Observatory, Edinburgh.
(Director, Dr. Copeland, Astronomer Royal for Scotland.)

The meridian observations made during 1904 have been restricted for the most part to the same programme as for several years past—viz. the zodiacal stars and heliometer comparison stars of Sir David Gill's lists and the clock-star list of the *Berliner Jahrbuch*. The total number of observations, all of which have been made by Mr. G. Clark, is somewhat less than the average of several years past; a result which is to be attributed to the long-continued periods of cloudy weather experienced in the latter half of the year. During the past four months only 18 or 20 nights could be classed as good observing nights, and on several of these observations were possible only for an hour or so. In the same period about 50 per cent. of the nights were completely overcast. Of the observations secured, 305 were of clock-stars, 714 of zodiacal stars, 71 of azimuth-stars, and 21 of the planets *Juno*, *Neptune*, *Saturn*, and *Jupiter*, making a total of 1111. All of these observations, with the exception of a few of the clock-stars, included measures of right ascension and declination. The instrumental errors, whenever possible, were determined both at the beginning and the end of each night's work, with satisfactory results as to the stability of the instrument. Reductions of the recent meridian observations have been carried on steadily during the year, and there is reason to hope that all the observations made up to the end of 1904 may be completely reduced to apparent place during the next few months.

The new reductions of the observations of stars made by the late Professor Henderson and Mr. Wallace at the Calton Hill Observatory during the years 1834-45, having been completed last year, have again been carefully examined and revised, and the MS., including introduction, annual results, and catalogue, finally prepared for the press. The work is now in the hands of the printer. At the request of Professor Boss a considerable number of positions of stars have been sent to him for utilisation in his investigation of standard right ascensions and declinations. As in last year, Dr. Halm has again had the able assistance in this work of Mr. Blackett, who has acted as temporary computer.

The spectroscopic observations of the rotation of the Sun have been continued throughout the year, and the greater part of the observations have been reduced. A preliminary paper on the results of 1901-3 was communicated to the Royal Society of Edinburgh and printed in their *Transactions*. Dr. Halm has also read before the same Society papers on Seeliger's theory of temporary stars, on the structure of the line and band series in spectra, and on the diurnal change of terrestrial magnetism,

which will appear in future numbers of the *Transactions* and *Proceedings* of the Society.

The 24-inch reflecting telescope has recently been equipped with a photographic plate carrier, designed by Mr. Heath and constructed by Mr. J. B. McPherson, engineer to the Observatory. It is provided with two slow-motion screws for moving the plate and guiding eyepiece in two directions at right angles to one another.

Several attempts were made by Mr. Clark to observe Encke's Comet, and comets 1904 *d* and 1904 *e*, with the 15-inch equatorial, but unfortunately without success, clouds or bright moonlight having on every occasion interfered with the observations.

Seismographical observations are made continuously and reported to the Seismological Committee of the British Association.

The Observatory supplies Greenwich mean time to Edinburgh and Dundee daily.

Meteorological observations are made continuously.

Cambridge Observatory (Director, Sir R. S. Ball).

Reduction of Photographs of Eros.—The reduction of a series of photographs of *Eros*, taken at nine observatories during the period 1900 November 7–15, was completed in June 1904, and a summary of the results communicated to the Society by Mr. Hinks (*Monthly Notices*, vol. lxiv. p. 701). The value of the solar parallax deduced from 295 exposures was $8''.797 \pm 0''.0047$. There is evidence of an oscillation in the place of the planet with a semi-amplitude of $0''.03$ and a period of $2^h 38^m$, half the complete period of variation of light.

Since July good progress has been made with an investigation of systematic differences between the published results of different observatories and in the formation of a standard system of comparison stars for the whole extent of the observations.

Twenty-three exposures to complete the Cambridge contribution of 112 exposures to the above-mentioned investigation were measured in January by Mr. Hinks, who has had the help in computation of Miss Bell and Miss Malden.

Meridian Circle.—The alterations and additions to the meridian circle mentioned in the last report were completed by Messrs. Troughton & Simms in April. During the summer the instrument was completely adjusted and reduced to a condition of steadiness, and the observation of Sir David Gill's Zodiacal Star Catalogue was resumed on September 15, since which date about 700 observations have been made by Mr. Hartley.

The observations for the second list of heliometer comparison stars have been sent to Sir David Gill.

Sheepshanks Equatorial.—Good progress has been made with the observation of the objects in the stellar parallax working list prepared in 1903. During the year 177 successful plates have been taken by Mr. Russell and 32 by Mr. Hinks; the number of exposures on each plate is usually four. Mr. Russell has measured 107 plates, and the reductions are well advanced.

Floating Zenith Telescope.—Mr. Cookson has returned to Cambridge from the Royal Observatory, Cape of Good Hope. He has removed his floating photographic zenith telescope from the small dome on the main building and installed it in a new building designed to avoid the effects of temperature changes and of wind. The instrument has been adjusted, and is now at work on a determination of the aberration constant by Küstner's method, and of the variation of latitude.

Self-recording Meteorological Instruments.—The Dines self-recording barograph mentioned in the last report was installed in the spring, and has been constantly compared with the standard barometer.

The Bendorf electrograph, with radium radiator, has been at work, with a few interruptions, since June.

The Callendar sunshine-receiver lent by Dr. W. E. Wilson has been mounted equatorially with a new form of driving mechanism, but is not yet working.

The Newall Telescope, Cambridge Observatory.
(Mr. H. F. Newall.)

The Newall Telescope was used for observations on sixty nights in the course of the year 1904; six possible observing nights were not utilised in November and December, the driving of the telescope having become defective.

Spectroscopic studies of the stars have been carried on as in recent years, principally in the determination of velocity in the line of sight. One hundred and twenty-six photographs of stellar spectra have been obtained by Mr. Bellamy relating to twenty-six stars, fifty-eight photographs relating to ten stars chosen as "velocity-reference-stars" observed in co-operation with other observatories. This work has been carried out with the four-prism spectroscope adjusted for H γ .

In the autumn one of the four prisms was removed, and in its place a prism of larger angle was inserted; the instrument was adjusted for $\lambda\lambda$ 4900–5890, and photographs have been obtained of the green part of the spectrum of several of the brighter stars for special investigations. This work had hardly been begun before it was interrupted by faulty driving of the telescope. After ten years of remarkably efficient work it seemed that the clockwork had become defective; this, however, was not the case, but it took a long time to trace the trouble to its real cause—namely, the loosening of a nut on the spindle of one of the anti-

friction rollers at the bottom of the polar axis of the telescope. The photographic work was not resumed till 1905 January 12. Now that every part of the mechanism has been so thoroughly overhauled, measurements are to be made and recorded of the power required to move the telescope, of the power transmitted by the clockwork, and so forth, for comparison with measurements when any future defect calls for rectification.

Provision is being made for making solar spectroscopic observations, and specially for testing the atmospheric conditions for such work at Cambridge with the large instrument. The interest in the results of this investigation has been enormously enhanced by the munificent bequest of £5000 made by the late Mr. Frank McClean, F.R.S., with the view of extending and improving the instrumental equipment of the Observatory. The preliminary work thus assumes a new aspect when it is begun with the immediate prospect of its being developed in the direction that experience may show to be desirable; and though it is our great loss that we have not now the benefit of his expert advice, it is a peculiar pleasure to have the work connected with the memory of Frank McClean—a benefactor who has shown in so many ways his desire to advance astrophysical science.

Dunsink Observatory.

(Director, Prof. C. J. Joly, Royal Astronomer of Ireland.)

The chief work during the past year consists in the reduction of the observations of the stars of Sir David Gill's zodiacal list which were made with the Pistor and Martin's meridian circle. All the stars observed have been reduced to 1900.0. The precessions and secular variations for the stars observed in 1900 have been computed, and the work of preparing the results for their final form is proceeding.

The opportunity afforded by the cessation of systematic observation with the meridian circle was utilised in having the instrument overhauled. The mirrors for the illumination were resilvered and traces of fungus were removed from the object-glass. A new reticle was also fitted. Two series of observations were made in order to determine the personal equation due to the magnitude of stars in transit. By means of a suitable series of screens the stars were observed over half the wires at full magnitude, and over the remaining half at about the eighth magnitude. The first series gave a fairly marked personal equation. As the star images during this series of observations were not particularly good, a new series was carried out after the object-glass had been readjusted. The personal equation deduced from the new set of observations was practically *nil*.

The errors of each degree division of each circle of the meridian instrument were also determined.

Three hundred and forty-seven stars were observed with the

meridian circle during the year. Of these, 165 were observed for clock-error and 182 for the personal equation determinations.

A number of photographs of nebulae and star clusters were taken with the Roberts equatorial. This is a reflector with a 15-inch mirror and a guiding telescope. A good deal of trouble has always been experienced with this instrument owing to the instability of the mirror in its cell. Frequently plates are spoiled owing to sudden displacements of the images, especially during long exposures. Some modifications were made in the cell during the past year, and the performance of the instrument is undoubtedly improved. There is, however, still at times a perceptible shift of the mirror.

Some measures of double stars were made with the South equatorial with the object of testing the suitability of the instrument for systematic work in this department. The imperfections of the driving-clock interfere seriously with the accuracy of the results. This instrument has, as usual, been employed on the first Saturday of each month in showing objects of interest to visitors.

The time service to Dublin has been continued, and it has been considerably improved by corrections for the temperature and for the barometric pressure deduced from a new set of tables compiled from observations of the clock-rate.

Durham Observatory. (Director, Prof. R. A. Sampson.)

The Almucantar has been used on fifty-two nights during the year, making in all 759 transits. Attention has been directed chiefly to experiment in the quantity of mercury used, screening from temperature variations, and other such matters; these experiments are still being carried on.

The discussion of the elements of *Jupiter's* satellites has proceeded, so that the elements of I. and II. are believed to be now very nearly in a final state; those of III. still require revision.

Glasgow Observatory. (Director, Dr. Becker.)

The determination of absolute positions of four stars in the immediate vicinity of the pole was continued with the transit circle. Eight years of observations are now available, and it is proposed to extend them over a whole period of the node of the lunar orbit. In the last three months the weather conditions were even worse than in former years: with the exception of two nights the sky was either not clear for a sufficiently long time or heavy mist made faint stars invisible.

The spectroscopic work was mostly of an experimental character. Worth mentioning are our attempts to photograph

the red and yellow region of the spectrum of *Jupiter*. The photographs confirm the existence of one dark band near C, while they contain no trace of those visually observed in the yellow.

A new sidereal clock by Riefler was installed in December.

A paper on "The Spectrum of Nova *Persei* and the Structure of its Bands as Photographed at Glasgow" has been published in the *Transactions* of the Royal Society of Edinburgh, vol. xli. Pt. II. (No. 10).

The time service and meteorological observations have been carried on as in former years.

Liverpool Observatory. (Director, Mr. W. E. Plummer.)

In the last Annual Report it was mentioned that it was proposed to measure some photographs made at other observatories, but that difficulty had been found in the lack of the necessary measuring apparatus. By the kindness of Professor H. H. Turner this deficiency has been supplied by the loan of a measuring machine. A plate of the *Hercules* cluster taken at the Yerkes Observatory has been measured in the past few months. The number of objects whose positions have been recorded is 2131. In the densest part of the cluster one star has been observed on an average in an area of ten square seconds. The constants of the plate have been determined, and other inquiries connected with the distribution of the stars in the cluster are now being prosecuted.

A good deal of attention has been devoted to comets, as in previous years. Many of the observations have been reduced, and these will be presented to the Society in due course. Double stars have also been observed occasionally.

The Observatory has to report no alteration in its staff or permanent equipment. The meteorological and seismological observations are continuously maintained. In connection with the routine work may be mentioned the distribution of time signals, the testing and rating of chronometers, the examination of sextants and other apparatus, for which the Mersey Docks and Harbour Board is prepared to grant certificates of test. Lectures in connection with the University of Liverpool are regularly given in the Observatory.

Radcliffe Observatory, Oxford.
(Director, Dr. Rambaut, Radcliffe Observer.)

During the past year very little routine work has been done with the transit circle. Occasional observations have been made for the determination of time and instrumental errors. The working parts of the instrument have been carefully tested. The condition of the micrometer screws of the microscopes and

eyepiece was examined in the manner described in the Radcliffe Observations, 1886, p. xi, with the satisfactory result that no sensible effect of wear could be detected. A re-determination of the horizontal flexure corroborated very closely the value for this quantity obtained in 1902 which had been used in the reductions. But the principal work in connexion with the transit circle was the examination of the errors of the pivots.

In previous reports references have been made to this subject, but hitherto all attempts to determine these minute errors have been unsatisfactory. This year a novel and highly sensitive method of testing the pivots has been adopted, and the errors have been measured with a remarkable degree of precision. The method employed and the results obtained are described in a paper communicated to the Society and published in the *Monthly Notices*, vol. lxv. 1, p. 56. This paper contains a table (p. 77) giving the corrections necessary to the Radcliffe Catalogue for 1890 to free them from this source of error.

The printing of the catalogue referred to in recent reports has had to be postponed for lack of funds, and accordingly other more pressing work has been allowed to interfere with the actual preparation of the copy for press. But the material is now complete, and it is hoped that the copy will soon be in the printer's hands.

The Barclay 10-inch equatorial has been used chiefly for observations of new or variable stars and comets. Observations of the brightness of Nova *Persei*, Nova *Aurigæ*, and Nova *Geminorum* were made on January 15, and of Mr. Stanley Williams's new or variable star (159, 1904) on October 7, 8, 11, 13, 18, December 3, 5, 7, 8, 12, and 16 (see *Monthly Notices*, vol. lxv. 2). On March 22 the occultations by the Moon of three stars in *Taurus* were observed, and on April 18 and 23 Brooks's Comet 1904 *a* was examined and its position approximately determined.

The preliminary work of getting the new equatorial into thorough working order, which was in progress at the date of last report, continued to occupy a great deal of time during the earlier months of the year. Several unexpected difficulties arose. Amongst others the illumination of the field of the guiding telescope and of the bifilar micrometer gave a good deal of trouble; but after a number of experiments a very satisfactory illumination was in both cases at length obtained. During the course of the long and tedious trials of the various parts of the instrument many plates were taken, some of which no doubt are of very little permanent value; but several photographs (*e.g.* those of the *Pleiades*, H vi. 33 and 34 [*Persei*], *Præsepe* [*Cancer*], M 38 [*Aurigæ*], Mr. Stanley Williams's Nova and other groups) have been preserved, and may, it is hoped, prove of use when an opportunity of measuring them presents itself.

During the summer a programme of stellar parallax work, according to the method proposed by Professor Kapteyn (*Bulletin de la Carte du Ciel*, tome i. p. 262), was arranged in

consultation with him. This work might have commenced at the beginning of September, but unfortunately the necessity of waiting for a special plateholder caused so much delay that it was found impossible to make a beginning until the middle of October, after which the state of the weather interfered very much with operations. Thirty-one photographs, each containing three separate exposures, have been made in connexion with this work, of which twenty-one have been carefully stored away undeveloped in tin boxes to be exposed again during the spring months, and finally once more in the following autumn, so as to obtain, in close juxtaposition on the plate, images of the stars at each of three successive maxima of parallax, in accordance with Professor Kapteyn's scheme.

Early in June a machine of a novel pattern for measuring photographs was supplied by Sir Howard Grubb. This instrument is constructed to measure plates of any size up to 12 in. $\times$ 12 in. So far the work done with it has been confined to measures for testing the micrometer screws and examining the division errors of the scales. Until quite recently a difficulty has been experienced in getting a sufficiently accurate scale for subdividing the *réseau* intervals; but it is expected that before long a scale satisfactory in every respect may be obtained. The errors of the screws are found to be exceedingly small.

Meteorological and earth-temperature observations have been carried on as heretofore.

University Observatory, Oxford.
(Director, Prof. H. H. Turner.)

The portion of the *Astrographic Catalogue* assigned to this observatory was completed in February last in MS. The first plates were exposed in 1892 January, and the work has gone on continuously until 1904 February 17, when the reductions of the last plate were completed. During the twelve years which have elapsed since the commencement of the work much has been learnt from experience, and some of the earlier plates could be improved. But the work can be reported complete, leaving revisions and additions to be made as opportunity offers. It is hoped that funds for printing the work will soon be provided by the Government and the University jointly; but the negotiations, in which the Royal Society has rendered kind and important assistance, are still proceeding.

Attention has now been directed more particularly to the *Eros* plates, many of which have been measured. Those falling within the period 1900 November 7-15, for which Mr. Hinks of Cambridge undertook a general discussion, were measured with attention to his suggestions, and the results sent to him for incorporation with others (*Monthly Notices*, vol. lxiv. p. 701).

The stereo-comparator presented to this observatory by

Mr. C. L. Brook, F.R.A.S., was set up in January last, and a number of plates have been compared during the year, but without finding anything worthy of special notice as yet. This, perhaps, is only what might have been expected.

The editing of the "Rousdon Variable Star Observations" occupied much of the time of the Director during the early part of the year (*Memoirs R.A.S.*, vol. lv., and *Monthly Notices*, vol. lxiv. p. 543). Other investigations have been of a minor character. During the early months Dr. J. H. Metcalf, of Vermont, U.S.A., continued his work on the measurement of plates (*Monthly Notices*, vol. lxiv. p. 437).

The Director visited the United States during the summer in connexion with the St. Louis Congress of Arts and Sciences, and gratefully acknowledges the cordial reception he met with at a number of observatories.

In recording the conclusion of the heavy piece of work on the Astrographic Catalogue the labours of three persons call for special recognition. Mr. F. A. Bellamy has taken practically all the plates and superintended the whole work throughout with unflinching devotion and care. It is pleasant to be able to mention that the University has conferred upon him the honorary degree of M.A. in acknowledgment of these special services. Mr. B. Gray and Mr. E. A. Gray have done the lion's share of the measures and reductions with an accuracy and neatness which could scarcely be improved. It is sad to chronicle their departure from the Observatory as the natural sequel to the completion of the work.

Temple Observatory, Rugby. (Director, Mr. G. M. Seabroke.)

The use of this observatory by members of the school has been increasing, and some of the boys are sufficiently advanced as to be allowed to go there alone at all times. Transit and double-star observations and photography of the Moon have constituted the chief work.

*Solar Physics Observatory, South Kensington.
(Director, Sir Norman Lockyer, K.C.B.)*

Observations of Sun-spot Spectra.—The Sun was seen on 241 days during 1904, and spot spectrum observations were made on 114 days, 181 spots being observed in the region F—D. The records continue to show that the chief lines affected are due to vanadium, titanium, and the "unknown" light-sources.

Daily photographs (glass negatives) of the Sun's disc are received from Dehra Dûn (India) and Mauritius, the gaps in the Indian record being filled up, as far as possible, by negatives from Mauritius. The negatives are forwarded to Greenwich for

reduction as they are required. A positive on paper accompanies each negative, and these are mounted on cartridge paper and then bound up into half-yearly volumes, the Mauritius prints being primarily used to fill the Indian gaps. The printing from Canon Selwyn's excellent Ely negatives is now complete, and affords a fairly continuous record of the changes on the solar disc from 1863 February 9 to 1874 February 25. The total number of prints thus obtained is 1655, of which 1481 have been mounted in a similar manner to the Indian prints.

The Spectro-heliograph.—A hundred and twenty-seven days were fine enough to warrant attempts being made to obtain monochromatic photographs of the Sun. Owing to its unfavourable location the instrument can only be used between April and November, and during that period 477 "K-light" negatives of the disc and 95 of the limb and disc combined were obtained. A number of these have been enlarged to 8-inch glass positives, and experimental measures are being carried out for the purpose of finding the most satisfactory method of determining the positions and areas of the calcium vapour clouds shown thereon.

A new 12-inch photo-visual Cooke objective, of 18 feet focal length, has been in use since April 9 for focussing the solar image on the primary slit, and this has produced a marked improvement in shortening the times of exposure. A brief description of this instrument and an account of the results so far obtained are in hand and will be submitted to the Society at an early date.

Stellar Spectra.—The instruments principally used in photographing stellar spectra were the 6-inch Henry prismatic camera, with one 45° objective prism; the 2-inch calcite-quartz prismatic camera; the 9-inch prismatic reflector, with one $7\frac{1}{2}^\circ$ objective prism; and the 36-inch reflector. Fifty-two spectra have been photographed with the first-named instrument, forty-two in the ordinary region and ten taken during focussing trials preparatory to photographing the green, F—D, region in the spectra of the brighter stars. The calcite camera has been chiefly used for photographing spectra of pairs of stars situated on the same levels, but on opposite sides, of the temperature curve based on the chemical classification, the purpose being to test the equality of temperature of such pairs. Altogether, twenty-nine negatives, including twenty-five different pairs of stars, were obtained, and besides these a number of trial exposures were made to determine the colour curves and ranges of various makes of dry plates. The spectra of fifteen of the fainter stars have been photographed with the 9-inch prismatic reflector. The pressure of other work and the delay in readjusting the rails, which are out of level owing to the subsidence of the concrete foundations on which they rest, have prevented any extensive employment of the 36-inch reflector; but the field of best definition has been determined, and the Hammersley 3-prism spectroscope, which is used in conjunction with this

instrument, has been cleaned, adjusted, and remounted in preparation for the photographing of the spectra of various nebulae and red stars which is now in progress.

Meteors.—No organised attempt was made to observe the *Perseid* and *Leonid* showers of 1904, but observations made during the intervals between routine work led the observers on duty to the conclusion that the former shower afforded a fairly rich display. Thirteen plates exposed in ordinary cameras by one of the observers on August 11 and 12 showed no trace of a meteor trail.

Laboratory Work.—A number of arc spectra of elements have been photographed in the region $\lambda 4800$ – $\lambda 5900$ with the 21-foot Rowland grating, using the third order. The 3-inch Cooke spectroscope has been used to obtain the arc spectra of various substances, including several mineralogical specimens submitted for analysis by the Geological Survey. Researches on the dissociation of gas from minerals under varying electrical conditions have been commenced and are still in progress.

Correlation of Solar and Meteorological Phenomena.—The time of the computing staff has been largely employed in continuing the reduction and plotting of published meteorological data on uniform lines for comparison with similar reductions of the solar records. The resulting tables and curves emphasise the close relationship between these two classes of phenomena, and form a valuable and ready source of reference for present and future work.

Publications.—Papers dealing with sun-spot variations, stellar temperatures, atmospheric pressure, magnetic storms and auroræ, the spectra of sun-spots and stars, enhanced lines and the spectrum of silicium have been communicated to the Royal Society during the past twelve months, some of them subsequently appearing as appendices to the *Monthly Notices*. Numerous papers dealing further with these subjects are in course of preparation.

Stonyhurst College Observatory. (Director, Rev. W. Sidgreaves.)

The 4-inch prismatic camera has been removed from the equatorial telescope and mounted on the polar axis of the "Cross" 7-inch reflector, of which mention was made in last year's report. The driving-clock, which was built for a greater polar axis, has been successfully geared to the smaller one, and runs the same very smoothly. The results at present are meagre but promising. The continuous night-cloudiness has frustrated the hope of obtaining an ample and succinct series of spectrographs of the binary or possibly multiple system of β *Aurigæ*; but the lines are measurably double on some of the plates, and sharp singles on others. Another projected series of γ *Cassiopeiae*

has suffered in the same way; there have been too many days between successive exposures, and many of the photographs are of inferior value owing to unfavourable atmospheric conditions.

The solar surface has been observed on 215 days, recorded by 213 drawings of spots and faculæ and two blank sheets.

Spectrographs of the larger spots have been taken with the grating spectrograph in the green and violet regions; and a considerable number of experiments have been made on the photography of the red end of the spectrum.

Mr. Edward Crossley's Observatory, Bermerside, Halifax.

The work of the Observatory has been resumed as in past years—viz. the observation of double stars, the phenomena of *Jupiter's* satellites, and the usual meteorological observations at 9 A.M. and 3 P.M.

Wolsingham Observatory. (Rev. T. E. Espin.)

The work of measuring the double stars of Herschel, and other stars which have been mostly neglected, between N. 30° and 40° , has been carried on; between thirty and forty new pairs have been detected as well. Most of these have been measured, though some of them are too difficult for the $17\frac{1}{4}$ -inch. The majority of the measures have been made since August, ill health preventing night work in the earlier part of the year.

Sir William Huggins's Observatory, Upper Tulse Hill.

The photography of the spectra of stars and other celestial bodies, which has been in progress for many years, is being continued.

Experimental work in the laboratory has included, in addition to the photography of terrestrial spectra, further experiments of the radiation of radium.

Rousdon Observatory, Lyme Regis, Devon.
(Late Sir C. E. Peek's; C. Grover, Observer in Charge.)

The building and instruments are maintained in good working order. The year has been decidedly favourable to astronomical work, and observations have been made on 141 nights. The 6.4-inch Merz-équatorial has been used in the observation of long-period variable stars, and 489 magnitude determinations

have been made. Argelander's method has been followed, as during the previous nineteen years. At each observation the light of the variable is estimated relatively to five comparison stars in the same field of view, the mean result being assumed to be the magnitude on the date of observation. About twenty-five long-period variables are under regular observation; and as most of these are circumpolar in this latitude, their light-changes are continuously recorded.

The occultation of *Aldebaran* by the Moon on February 24 was well observed: the star was clear and well defined, and disappeared instantaneously at 5^h 53^m 30^s G.M.T. *Aldebaran* was again occulted in the early morning of July 9 and in bright sunshine, but the star was beautifully defined and disappeared instantaneously at 17^h 28^m 28^s.

The following occultations of stars were observed 1904 March 22. The disappearances at the dark limb were all instantaneous:—

			h	m
78 <i>Tauri</i>	magnitude 5.3	disappeared	10	1 9.9
6 ¹ <i>Tauri</i>	"	3.9	10	2 25.9
D.M. + 15° 633	"	6.5	10	4 32.9

Encke's Comet was observed on seven nights between November 24 and December 18. On November 24 it was large and diffuse, with but slight central condensation. By December 10 it had considerably diminished in size, but was brighter with more central condensation, and on December 18 it was very faint owing to moonlight. On November 28 it was in the same field of view with the cluster 15 *M Pegasi*, and the contrast between the large, faint, and diffuse comet and the small and bright star cluster was most interesting.

Starfield Observatory, Crowborough Beacon.

(Late Dr. Isaac Roberts's; W. S. Franks, Observer in Charge.)

Subjoined is a list of the nebulae and clusters photographed with the 20-inch reflector of the above observatory during the year 1904 up to the date of Dr. Roberts's death on July 17. Since that time the photographic work has been practically suspended, and it is not possible at present to say whether it will be renewed or not. The meteorological observations have been regularly kept up, so that there should be no break in their continuity. In the following list it has been deemed expedient to omit the *co-ordinates* of the objects in order to economise valuable space; they can be easily enough identified by reference to the well-known catalogues of Dr. Dreyer. They are placed, of course, in order of R.A.

List of Photographs taken in 1904.

	Expos. m		Expos. m
Neb. H V. 16 Andromedæ ...	90	Neb. H V. 26 Leonis Minoris ...	90
Neb. H I. 159 Cassiopeïæ ...	90	Neb. H V. 23 Ursæ Majoris ...	*88
Cl. H VII. 42 Cassiopeïæ ...	60	Neb. H I. 79 Ursæ Majoris ...	90
Neb. H I. 108 Piscium ...	90	Neb. H II. 81 Leonis ...	90
Cl. M. 103 Cassiopeïæ ...	60	Neb. H II. 50 Leonis ...	90
Cl. H VI. 31 Cassiopeïæ ...	60	Neb. H II. 30 Leonis ...	90
Neb. Index Cat. 155 Cassiopeïæ	90	Neb. H II. 160 Leonis ...	90
Neb. N.G.C. 674 Arietis ...	90	Groombridge 1830 Ursæ Majoris	15
Cl. M 34 Persei ...	60	Neb. H II. 162 Virginis ...	90
Neb. N.G.C. 1170 Arietis ...	90	Neb. H II. 132 Virginis ...	90
Neb. H IV. 17 Eridani ...	90	Neb. H I. 95 Comæ ...	90
Neb. Index Cat. 348 Persei ...	90	Neb. H II. 749 Canum Venat. ...	90
Neb. N.G.C. 1499 Persei	2 ^h 30	Neb. H I. 83 Comæ ...	90
Cl. H VII. 60 Persei ...	60	Neb. H I. 124-5 Virginis ...	*70
Cl. H VII. 61 Persei ...	60	Neb. H II. 95 Virginis ...	90
Neb. H I. 158 Eridani ...	54	Neb. M 94 Canum Venat (2) ...	30
Neb. H II. 289 Leporis ...	90	Neb. H I. 162 Virginis ...	90
Cl. M 38 Aurigæ ...	90	Neb. H V. 3 Virginis ...	90
Cl. M 36 Aurigæ ...	90	Neb. H II. 664 Canum Venat. ...	90
Neb. Index Cat. 430 Orionis ...	90	Neb. H II. 691 Boötis ...	90
Cl. M 37 Aurigæ ...	90	Cl. H VI. 9 Boötis ...	60
Neb. h 373 Monocerotis ...	90	Neb. H II. 650 Boötis ...	90
Neb. H IV. 20 Monocerotis ...	90	Cl. M 14 Ophiuchi ...	2 ^h 0
Cl. H VI. 2 Geminorum ...	60	Neb. h 1989 Herculis ...	90
Cl. M 50 Monocerotis ...	90	Neb. H II. 199 Ophiuchi ...	*70
Cl. H VIII. 11 Geminorum ...	30	Neb. Index Cat. 1274-5 Sagittarii	90
Neb. H IV. 45 Geminorum ...	30	Neb. Index Cat. 1276 Serpentis	90
Neb. H I. 218 Lyncis ...	90	Cl. H VII. 30 Sagittarii ...	60
Cl. H VI. 1 Geminorum ...	60	Neb. M 16 Clypei ...	2 ^h 0
Cl. M 46 Argûs ...	90	Cl. H VI. 23 Sagittarii ...	2 ^h 0
Cl. M 47 Argûs ...	60	Neb. M 57 Lyne ...	20
Cl. H VI. 37 Argûs ...	*50	Cl. H VIII. 13 Aquilæ ...	30
Neb. H II. 908 Ursæ Majoris ...	90		

[Mrs. Roberts wishes it to be known that all the photographs will be carefully preserved by her at Château Rosa Bonheur, By Thomery, Seine-et-Marne, France, and will be available for reference.]

* Stopped by clouds.

Mr. Saunder's Observatory, Crowthorne, Berks.

Four of the Paris negatives of the Moon have now been completely measured, the results prepared for publication and communicated to the Society. In all, 2302 measures have been made of 1433 points. Of these, 38 points have been measured on all four plates, and from these it has been deduced that the radius of the Moon directed towards the Earth is about half a mile longer than the polar radius. Not much reliance is placed upon the absolute value obtained, but the result of the investigation shows that with further measures a satisfactory result may be expected, and that the elongation is small.

It is purposed to measure next two of Mr. Ritchey's negatives taken with the Yerkes 40-inch. In a preliminary examination of one of these a small unrecorded crater was noticed on the floor of *Ptolemæus*, a formation which has been kept under close examination with the telescope for some years. Its existence has since been verified, but it is, even under favourable conditions, a difficult object in a 7-inch refractor, and its detection on the photograph affords another proof of the great advances Mr. Ritchey has made.

The telescope has been used chiefly for minute study of special regions on the Moon.

The photographic measures have all been made by Mr. J. A. Hardcastle. Considerable help in the reductions has been received from Mr. B. G. C. Gray, and Mr. J. C. W. Herschel has made an index map of the points measured.

Daramona Observatory, Street, Westmeath. (Dr. W. E. Wilson.)

The weather during the past year has been the worst yet recorded for observational work.

A quartz train spectroscope was obtained with the object of photographing the ultra-violet spectrum of sun-spots, but it could not be used.

The differential bolometer for recording continuously the intensity of solar radiation has been sent to Cambridge Observatory, and it is hoped will give in time a valuable record.

Hong Kong Observatory. (Director, Dr. W. Doberck.)

(Report for the years 1902, 1903, and 1904.)

Weather forecasts and storm warnings and the other meteorological work is continued, and means have been taken of twenty years' hourly readings and eye observations. Absolute magnetic observations have been made at regular intervals during each year.

The time service is continued, but the time of the meridian eight hours east of Greenwich has been adopted. In 1902 the number of transits observed was 2842, in 1903 1067, and in 1904 1414. The observations of transits of southern stars were finished in July 1904, and a catalogue of over 2000 southern stars is in the press. It depends upon about 16,000 transits. The probable error of a right ascension determined from eight transits reduced to the equator is $\pm 0^s.011$. Stars of the sixth magnitude and brighter stars were screened so as to appear of about magnitude $6\frac{1}{2}$ or 7, which is about the magnitude of the greatest number of stars observed. The light-equation, if any, is therefore very small. The magnitudes were carefully estimated as often as possible, and a table of corrections was constructed for reducing the recorded magnitudes to the S.M.P. The probable error of an observed magnitude is 0.2 on the S.M.P. scale. As many of them were observed eight times in the course of the six years, the results are just as accurate as those determined photometrically. Possibly magnitudes directly estimated are even better than those obtained by aid of photometers, but the latter are required for settling a fixed scale.

About 500 micrometrical measurements of double stars, mostly southern pairs, were made at Hong Kong, and nearly double that number at the University Observatory, Copenhagen, where the Director spent about a year during his leave of absence from Hong Kong.

The recalculation of the orbits of double stars has been continued and new orbits of *Castor*, ζ *Sagittarii*, ξ *Boötis*, β 416, ϕ *Ursæ Majoris*, 99 *Herculis* = A.C. 15, and *Sirius* have been published in the *Astronomische Nachrichten*, where also papers on the distribution of double stars and on the accuracy of the Markree observations of double stars have been printed. In the former paper the preponderance of binaries in certain hours of right ascension has been pointed out; in the latter the systematic errors are proved to depend upon the definition and steadiness of the images.

The fourth edition of *The Law of Storms in the Eastern Seas* has been printed. Twenty annual volumes have been issued; and as they now contain investigations of typhoons, climate, &c., as complete as can be carried out with the instrumental outfit at this observatory, it is intended to discontinue this series.

Kodaikānal and Madras Observatories.
(Director, Prof. C. Michie Smith.)

The year was, on the whole, a very favourable one for observations, and at Kodaikānal there were only twenty-two days on which no solar observations were possible. Photographs of the Sun were taken with the Dallmeyer photoheliograph on 264 days, and could have been taken on more had it not been

for a want of suitable plates early in the year. Sun-spots were observed visually on 344 days, and sketches were made of important details. In all, 236 new groups were observed during the year. The smallest number of new groups appearing in any one month was eleven in February and, the largest, twenty-nine in December. The mean daily number of groups visible varied from 2·3 in February to 5·0 in December.

Sun-spot spectra were observed on 227 days, and attention was given, not only to widened lines, but also to the behaviour of hydrogen and helium lines in and near spots.

Prominences were observed on 251 days, but on twenty-one of these it was not possible to complete the work before clouds came up. All prominences are sketched and the heights of the more important ones are measured. Rapidly changing prominences are followed for some time and repeated sketches are made. The spectra of a number of eruptive prominences have also been studied.

The spectroheliograph, made for the Observatory by the Cambridge Scientific Instrument Company, was received in August, and was brought into regular use in October as soon as the buildings for it were sufficiently advanced to permit of the sliding roof covering the siderostat being moved. Since then it has been employed on every fine day except during a great part of November, when the director was absent from Kodaikānal. The instrument is a very fine one, and promises to give excellent results.

Meteorological observations and earthquake records with the Milne horizontal pendulum have been continued as in former years.

A European assistant has been sanctioned for the Observatory, but has not yet joined the staff.

Astronomical work at Madras was, as for some years past, practically confined to the observations necessary for the efficient maintenance of the time service.

Melbourne Observatory. (Director, Mr. P. Baracchi.)

Meridian Work.—The following observations were made with the 8-inch transit circle :—

				Observations in R.A.	Observations in N.P.D.
Clock stars ...	...	...	...	578	—
Azimuth stars	...	...	...	337	71
List stars ...	...	...	...	1432	1442
Miscellaneous	...	...	...	3	3
Total	...	...	...	2350	1516

The list stars were selected from the Melbourne Astrophotographic Catalogue plates to serve as standard stars for the

reduction of those plates. The total number of these standard stars now completely observed three times or more is 4912.

Astrophotographic Work.—The following table shows the number of regions photographed :—

	Passed as Satisfactory.	Rejected.	Total Number passed as Satisfactory.
Chart plates with triple exposure of 30 ^m each	110	4	482
Catalogue plates, second series ...	56	3	291
Test plates on South Polar Regions	30	—	—
Test plates on Oxford Type Charts	9	—	—
Plates for trails, adjustment of focus, centre, &c.	27	—	—

The photographic record of the variation of the magnetic elements, of meteorological elements, and earth tremors has been continued throughout the year without interruption.

The usual routine work in connection with the various services required by the public, as—

Time service,
Weather service,
Registration of tides,
Rating chronometers,
Testing of instruments,
Verification of standard weights and measures &c.—

have been carried out as in former years.

Sydney Observatory.

(*Mr. H. A. Lenehan, Acting Government Astronomer.*)

In January the Public Service Board separated the work of the departments of the Observatory, the meteorological branch of the work, heretofore carried on under the direction of Mr. Russell in conjunction with the astronomical work, was put under the charge of the first meteorological assistant, Mr. H. A. Hunt, and the astronomical portion under Mr. H. A. Lenehan, who had the full control of the two departments under his guidance. This arrangement will terminate on 1905 February 28, when Mr. Russell will retire from the service.

Early in the year Professor Otto Klotz, the Government Astronomer of Ottawa, Canada, visited Sydney in connexion with the latitude and longitude of the stations of the Pacific Cable route to Australia and New Zealand, and determined the difference of longitude between Sydney and Southport (Queensland), and the differences between Wellington and the terminal station at Doubtless Bay (New Zealand), Sydney having pre-

viously determined the longitude of Wellington. Professor Klotz also took observations at Sydney for personal equation.

Later in the year Dr. O. Hecker, of the International Geodetic Association, visited this Observatory. His mission was to determine the gravity of the Earth at various stations throughout the world: this he expects to complete by the end of March next. He also took magnetic observations for inclination and declination; but as the electric disturbance of the city interfered with the observations, a stone pillar was removed from the Observatory to Red Hill Branch, and there cemented into position. On this pier he made a successful series of observations with the most approved modern instruments. At the end of June Dr. Hecker left for San Francisco to continue his work. Sydney was the second place he had visited, results having previously been determined at Melbourne.

Two sets of time signals with Washington (U.S.A.) have been received, with very satisfactory results—viz. on 1904 January 1 and September 8, through the Pacific Cable.

Repairs to the floor and building at Red Hill Branch have been carried out, and new triangular wires have been placed in position, 7 seconds of arc apart, in the finder of the photographic telescope, so that three equidistant pictures can be taken.

Transit Work.—Mr. W. E. Raymond, who has this work in hand, was incapacitated by illness for some months, and although the assistance of a special officer, Mr. C. J. Merfield, was placed at the disposal of the Observatory, this circumstance interfered with the results obtained. During the early part of the year rain and cloud, and in the latter portion hot and dusty weather, rendered the seeing of stars of ninth and tenth magnitudes very difficult, and on many evenings the work had to be abandoned.

The equatorial has been in use during the year, but not on any special work. When permanent arrangements are made for the Director to succeed Mr. Russell, the equatorial will be put into constant use.

In November a small house was erected over the magnetic pier at Red Hill Branch, and the magnetic work has been started. The results compare very well with the last position determined at the Sydney Observatory—viz. 9 deg. 34 min. 78 sec. E.

Details of the Work.—

Number of R.A. observations of stars	...	2248
„ N.P.D. „ „	...	1839
„ R.A. „ of Sun	...	469

making a total of 2717 R.A. observations.

The 9 A.M. collimations, 300; level, 300; nadir, 300. The 9 P.M. level, 127; nadir, 127; azimuth determinations, 172.

The reductions of previous years' astronomical observations are in a very forward state, and it is hoped that sanction will be

given during the present year for printing the accumulated results now in manuscript.

The visitors' list for the year has been increased; no fewer than 1167 were shown over the Observatory, of whom 542 attended during the evenings, and on sixty occasions Mr. Lenehan gave lantern lectures and demonstrated with the equatorial. These visits took up a considerable time from the usual duties of the Observatory.

Mr. J. W. Short, astronomical photographer, gives the following results of his year's work with the Astrographic Telescope at Red Hill Branch:—

Eighty-seven chart plates, each $1\frac{1}{2}$ hour's exposure; 115 plates exposed. The preparation of a number of star lantern slides ordered by the late Minister for distribution; magnetic work which was commenced at the end of the year and other duties occupied much available time. To these and other causes the small number of plates taken is due.

Meteorology.—The number of weather charts issued was 22,100. Forecasts have been telegraphed daily to 63 stations in N.S. Wales; 4112 charts of daily rainfall and 888 monthly charts with percentages of rainfall over the State.

Climatology.—Fifty-six new stations have been established, making in all 1903, of which 1863 send monthly returns; and 40, annual returns.

Mr. W. C. Graham reports that 977 volumes have been distributed—a number considerably below that of last year, owing to delay at the Government Printing Office in completing the annual publication; 1200 volumes have been received during the year.

It is again the Director's pleasing duty to record his appreciation of the work of each officer of the staff of the Sydney Observatory, who by their industry helped in bringing the year's work to a successful issue.

Joint Report of the Government Astronomers of New South Wales and Victoria on the Measurement of the Sydney and Melbourne Plates of the Astrophotographic Catalogue.

This work is being done at the Melbourne Observatory by a special Bureau, maintained at the joint expense of the Governments of New South Wales and Victoria, as stated in previous reports.

The measurements during the whole of the year 1904 were made with the two measuring machines made by the Repsolds' on the plan of Sir David Gill, which have continued to give full satisfaction.

Mr. Russell's new measuring machine, described by him in *Monthly Notices*, vol. lxiii, page 39, has been on trial for a con-

siderable time, but was not required for systematic use during the year. The plates were measured in two positions, direct and reverse, and the measures passed as satisfactory if they agreed within $0''.6$.

The plates measured are :—

90 Sydney plates, containing 44,958 stars.

64 Melbourne plates, containing 39,924 stars.

The total numbers of plates now fully measured are :—

314 Sydney plates, containing 176,019 stars.

576 Melbourne plates, containing 187,267 stars.

There were unavoidable delays and interruptions in the work during the year owing to changes in the staff and the training of new observers.

Lovedale Observatory, South Africa. (Dr. Alex. W. Roberts.)

The work of this Observatory during 1904 has been, as in previous years, the observation of variable stars south of -30° .

The number of stars under regular examination is 102, and the number of observations made 3500.

The variation of stars of the close binary type is estimated by the Cooke prismatic telescope. This instrument yields measures freed from position error.

Variable stars of both the short-period and long-period class are kept under observation with either the 1-inch or the $3\frac{1}{4}$ -inch telescope.

During the year a system of standard stars from 2.0 mag. to 10.0 mag. has been determined by the method of sequences and limiting apertures. It is proposed during 1905 to extend this system down to 11.0 mag.

The magnitudes of the comparison stars surrounding three variable stars of the close binary type—*V Puppis*, *X Carinæ*, *R R Centauri*—have been determined by means of the Oxford wedge photometer.

Mr. Tebbutt's Observatory, the Peninsula, Windsor, N.S. Wales.

In consequence of the observer's advanced years, active work has been discontinued at this Observatory. The only observations made during the year 1904 are the following comparisons with the filar micrometer on the 8-inch equatorial :—

Objects Observed.					Nights of Observation.	Number of Comparisons.
Uranus	...	...	...	...	8	95
Ceres	...	...	...	...	1	10
Hebe	...	...	...	...	13	155

Rough observations of Encke's Comet were obtained on November 30 and December 1, but it was too faint and diffused for good work.

In addition to the astronomical work, the usual meteorological observations were made during the year.

NOTES ON SOME POINTS CONNECTED WITH THE PROGRESS
OF ASTRONOMY DURING THE PAST YEAR.

Discovery of Minor Planets in 1904.

Fifty-nine new planets were discovered, or first announced,
in 1904 as follows :—

Letter and Number.	Date of Discovery.	Discoverer.	Letter and Number.	Date of Discovery.	Discoverer.
MY ...	1904 Jan. 10	Dugan	OC 535	1904 May 7	Dugan
NB 521	" " 10	"	OD ...	" " 11	"
NC 522	" " 10	Wolf	OE ...	" " 13	Wolf
ND 523	" " 27	Dugan	OF 536	" " 11	Peters
NE ...	1903 Nov. 26	Hirayama	OG 537	" July 7	Charlois
NF ...	" Dec. 15	Peters	OH ...	1903 Apr. 28	Peters
NG ...	" Oct. 27	Götz, Wolf	OJ ...	" June 29	"
NJ ...	1904 Mar. 4	Wolf	OK 538	1904 July 18	Götz
NK ...	1901 Jan. 17	"	OL 539	" Aug. 2	Wolf
NL ...	" May 9	"	ON 540	" " 3	"
NM ...	1902 Oct. 8	Götz	OO 541	" " 4	"
NN 524	1904 Mar. 14	Wolf	OP ...	" " 14	"
NO 525	" " 14	"	OQ 542	" " 15	Götz, Kopff
NQ 526	" " 14	"	OR ...	" Sept. 6	Kopff
NR 527	" " 20	"	OS ...	" " 5	"
NS 528	" " 20	"	OT 543	" " 11	Götz
NT 529	" " 20	"	OU 544	" " 11	"
NU ...	1902 " 10	"	OV ...	" " 11	Kopff
NV 530	1904 Apr. 11	"	OX ...	" " 19	"
NW 531	" " 12	"	OY 545	" Oct. 3	Götz
NX ...	" " 16	"	OZ ...	" " 9	Wolf
NY 532	" " 20	"	PA 546	" " 10	Götz
NZ 533	" " 19	Dugan	PB 547	" " 14	"
OA 534	" " 19	"	PC 548	" " 14	"
OB ...	" " 21	Wolf	PD ...	" " 15	"

Letter and Number.	Date of Discovery.	Discoverer.	Letter and Number.	Date of Discovery.	Discoverer.
PF ...	1904 Oct. 16	Wolf	PM 551	1904 Oct. 16	Wolf
PG ...	" " 13	"	PN ...	" Dec. 14	"
PI ...	" " 15	"	PO 552	" Nov. 16	"
PK 549	" " 15	"	PP 553	" Dec. 14	"
PL 550	" " 16	"			

NE was discovered at Tokio ; NF, OF, OH, OJ at Washington ; OG at Nice ; the remainder at Heidelberg.

The following planets, unnumbered at the date of the last report, have since received permanent numbers : LY 513, MB 514, ME 515, MG 516, MH 517, MO 518, MP 519, MV 520, PK 549, PL 550, PM 551, PO 552, PP 553.

The following planets do not receive permanent numbers, not having been sufficiently observed : LW, LX, LZ, MC, MD, ME, MK, MM, MN, MQ, MR, MS, MT, MU, MW, MX, MY, NE, NF, NG, NJ, NK, NL, NM, NU, NX, OB, OD, OE, OH, OJ, OP, OR, OS, OV, OX, OZ.

The following identities have been established : MZ with 409 *Aspasia*, NA with 505, NH with 200 *Dynamene*, NP with 255 *Oppavia*, OM with 236 *Honorio*, OW with 485, PE with 178 *Belisana*. The following identities are probable : OH with 353 *Ruperto-Carola*, OJ with 411, PH with 157 *Deianira*, one of the long-lost planets.

The following identities were at first suspected but negated : NF with DW, MV with 316 *Goberta*, MY with MP, NJ with 310 *Margarita*.

The following planets have been named : 394 *Arduina*, 460 *Scania*, 496 *Gryphia*, 498 *Tokio*, 499 *Venusia*, 509 *Jolanda*, 512 *Taurinensis*, 516 *Amherstia*, 521 *Brixia*, 532 *Herculina*.

NF seems to have a very eccentric orbit, the value 0.4 being found for the eccentricity ; NW was moving north at the unusual rate of 23' daily ; NY (*Herculina*) was of magnitude 9.0 at discovery, which is unusually bright for a modern discovery ; NM must have been near DW in 1902, but is not identical with it ; NK, NL may be a single planet, in which case it would have an interesting orbit.

433 *Eros* will be in opposition early next August in south declination 13° : its magnitude will be 11.2, the circumstances being similar to those at discovery in 1898. The *Jahrbuch* for 1907 contains an ephemeris.

Popular Astronomy for December 1904 contains an article by Mr. B. L. Newkirk on the twenty-two asteroids discovered and endowed by the late Professor Watson. The study of their orbits has been undertaken by the Berkeley Observatory under the supervision of Professor Leuschner, and it is stated that with the exception of the missing planet, 132 *Æthra*, the work is in a forward state. It is conjectured that the orbit of

132 *Ethra* has been completely altered by the action of *Mars*, and Miss Hobe is shortly going to attempt to deduce the present orbit. It is, however, difficult to see how *Ethra* could ever approach near enough to *Mars* to suffer large perturbations unless the accepted elements of the former are utterly erroneous; for, according to these, the latitudes of the planets are widely different at the point of approach. However, all will hope that the researches may lead to the recovery of the planet, whose orbit is interesting from its large eccentricity and from the fact that its period is almost exactly one-third of *Jupiter's*.

The orbits of planets 505, 521 approach each other within about one-third of a million miles, and the planets actually made a close approach to each other in 1903 November. It is not, however, probable that their mass is great enough to cause any sensible perturbations even at that small distance.

A. C. D. C.

Saturn's Ninth Satellite, Phœbe.

The discovery of *Phœbe* was first announced in 1899 from photographs taken in Arequipa in 1898, but its complete confirmation can only be said to date from 1904. A long period of silence followed the first announcement, which, as Professor W. H. Pickering explains, was due partly to his attention being called off by his photographic work on the Moon and partly to the fact that *Phœbe's* orbit has an unexpectedly large eccentricity, which made its apparent distance from *Saturn* in 1900 much greater than was anticipated, so that it remained undetected for a time. At length the idea occurred to him to extend the region of search on the plates, and his perseverance was rewarded by the detection of several images of the satellite.

It was found possible to construct a direct orbit which would represent the positions of 1898 and 1900 without large errors. However, when search was made on the plates taken at Arequipa in the spring of 1904 no trace of *Phœbe* could be found in the calculated position, but it was at length found a considerable distance away. Two hypotheses were now possible: (1) the object photographed in 1904 was not the same as that recorded in the earlier years; or (2) if the same object, it must be moving round *Saturn* in the opposite direction to that of all the other satellites of that planet. The latter was such an unexpected result that it was not received without hesitation. However, on examination so many lines of evidence converge to establish it that there can be little doubt of its reality: (1) viewing the orbit as a circle and neglecting the eccentricity, the change in the pose of the apparent ellipse in the different years is in accord with the retrograde hypothesis, and with that only; (2) taking the eccentricity into account, the position of the *perisaturnium* in the different years led to the same result; (3) a third line of

evidence, not in itself convincing, but adding weight to the others, is that the observations since 1898 appear to show a *direct* motion of the node of the orbit, which would imply that the satellite moves in the opposite direction. As to the suggestion of two different satellites, it seems enough to say that the possibility of satisfying all the positions from 1898 to 1904 (except a few which had been already noted as doubtful, from their extreme faintness) by a single orbit renders very improbable the hypothesis of two different orbits related to each other in such an extraordinary manner.

Professor Berberich makes the curious suggestion in *Ast. Nach.* 3988 that the object seen in 1904 may not be a satellite of *Saturn* at all, but an asteroid whose orbit lies near *Saturn's*. This would be a reasonable suggestion if we had only a few isolated observations last year; but considering that there is a continuous series extending from April 16 to November 10, made with three different instruments—the Bruce reflector at Arequipa, the Yerkes refractor, and the Crossley reflector at Mount Hamilton—and that all the positions are in satisfactory accord with the hypothesis of elliptical motion round *Saturn*, Professor Berberich's suggestion seems quite untenable.

A perfect agreement with elliptical motion is not to be expected, for, as Professor Newcomb and others have pointed out, the solar perturbations of *Phæbe* must be very large; in particular, the evection coefficient is about 4° , which would produce a shift of over $2'$ in its geocentric position. Newcomb estimates that the apse would have a retrograde movement of between $\frac{1}{2}^\circ$ and 1° annually, so that this should be sensible in a few years, especially as the eccentricity of *Phæbe's* orbit is so large (about 0.22, nearly double that of *Hyperion*, which had the most eccentric orbit of any satellite previously known).

The period of *Phæbe* is 547 days, or $1\frac{1}{2}$ year; its distance from *Saturn* 0.0862 in astronomical units, or 8 millions of miles. Its magnitude in opposition is probably between 15 and 16, from which its diameter is estimated as about 150 miles. Seen from *Saturn*, it would only appear as a star of the fifth or sixth magnitude, and would have a disc of about $4''$ in diameter!

One explanation given of the retrograde motion is that the satellite is not an original member of the Saturnian system, but was captured later. Professor W. H. Pickering makes an alternative suggestion—viz. that originally *Saturn* rotated backwards, and that *Phæbe* was born at this period, while solar tides turned the planet over before the other satellites were born. Others had already pointed out that if the planets were formed from nebulous rings the inner portions would move quickest round the Sun, and a retrograde rotation would result. But the suggested action of the solar tides does not seem to have yet been verified mathematically, and till this is done the theory should be received with caution.

Within the last few days the announcement has been received

of the discovery of a similar very distant satellite of *Jupiter*. The search for this was doubtless suggested by the discovery of *Phœbe*. If its existence is confirmed, and if its motion round *Jupiter* should prove to be retrograde, it will undoubtedly lend an air of verisimilitude to Professor Pickering's hypothesis; but if direct, it will seriously discount it.

In any case, the discovery of *Phœbe* excites our admiration as a great optical triumph and adds a new and unexpected feature to the solar system.

A. C. D. C.

The Comets of 1904.

The following comets have been discovered during the year :—

Brooks's Periodical Comet of 1889, V., seen at the Lick Observatory on 1903 August 20, and followed at the Washington Observatory till 1904 February 15.

Comet *a*, 1904, discovered by Mr. Brooks, of Geneva, U.S.A., on April 16. Particular interest attaches to this discovery, since the examination of plates taken previous to the announcement disclosed earlier positions. Both Professor Pickering at Harvard and M. Rudaux at Domville had secured places. The comet was very generally observed throughout the summer and autumn. The orbit is apparently parabolic and distinguished by the large perihelion distance of 2.7 R.

Encke's Comet, first traced on a photographic plate taken at the Heidelberg Observatory with an exposure of three and a half hours on September 11. The comet was not generally observed till the end of October; but the circumstances were favourable for observers in the Northern Hemisphere, and throughout November and December many observations were secured. Towards the end of the latter month the comet was too close to the Sun for observation. The comet makes a close approach to *Mercury* at this return.

Tempel's Second Comet (1873 II.) was found by M. Javelle at Nice on November 30. The ephemeris to assist discovery was prepared by MM. Schulhof and Corniel, and represents the path of the comet with considerable exactness. The object is visible in the evening sky, being near *Venus*; but though the position may become slightly more favourable the brilliancy is decreasing.

On December 17 M. Giacobini, of Nice, detected a new comet which is still being observed. The comet is at a great distance both from the Sun and the Earth, so that the brilliancy alters slowly; but since the object has considerable north declination it is likely to be observed for some time.

On December 30 M. Borrelly, of Marseilles, found a telescopic comet which, like the preceding, is still under observation. On the form of the orbit it is premature to pronounce an opinion. The comet is near the equator, moving north, and diminishing in brightness.

The comets known as D'Arrest and Winnecke passed through perihelion without being seen.

Definitive orbits of the following comets have been published during the year :—

Comet.	Character of Orbit.	Calculator.	Authority.
1845 III.	Elliptical	Peck	<i>Ast. Jour.</i> vol. xxiv.
1887 II.	Elliptical	Stechert	<i>Ast. Nach.</i> No. 3957
1889 IV.	Elliptical	Horn	<i>Denksch. Wien. Ak.</i> 74
1890 III.	Parabolic	Rheden	<i>Sitz. Wien. Ak.</i> 113
1898 X.	Elliptical	Scharbe	<i>Ast. Nach.</i> vol. clxiv.

Professor Lane Poor, continuing his researches on Brooks's Periodic Comet of 1889, 1896, 1903, has concluded that it is not identical with Lexell's Comet of 1780.

W. E. P.

Progress of Meteoric Astronomy in 1904.

Quadrantids.—Very cloudy weather veiled this shower. On January 3, 12^h 30^m to 13^h 25^m G.M.T., Mr. Henry, of Dublin, counted 17 meteors, eight of which were at least equal to first-magnitude stars.

Lyrids.—Overcast skies also affected the visible return of these meteors, and few of them were seen.

Perseids.—This display was very fully and satisfactorily observed. From the whole of the reports the meteors appear to have been a little more abundant than usual, with a maximum on the morning of August 12.

Professors Perrotin and Maynard observed the shower from the summit of Mount Mounier, and on the five nights August 9–13 counted 1184 meteors, of which 941 were *Perseids*. Maximum between 13^h and 16^h August 11, horary number 92, chief radiant near γ *Persei*.

Mr. W. Wetherbee, of Barre, N.Y., on August 11, in less than 3^h, counted 154 meteors, including 116 *Perseids*.

Mr. P. M. Ryves, of Uxbridge, on August 11, between 9^h 45^m and 13^h 45^m, observed 160 meteors, including 99 *Perseids*.

M. Lucien Libert, at Havre, on August 11 to 20 saw 339 meteors, and noted the motion of the *Perseid* radiant very distinctly between August 11 and 16.

Mr. A. King, Leicester, on August 11, between 10^h 17^m and 14^h 20^m, observed more than 105 meteors, of which more than 80 were *Perseids*. At end of watch the horary rate was 53 and increasing. He regarded the shower as fairly rich and traced the easterly drift of the radiant.

MM. Biesbroeck and Philippot, in Belgium, on August 10 to 13 observed a great number of *Perseids* and other meteors, and derived the mean radiant at $45^{\circ}34' + 56^{\circ}47'$. The comparative figures for the orbit of the meteors and of Tuttle's Comet 1862 III. were computed as follow :—

<i>Perseids.</i>	Comet 1862 III.
$\pi = 291^{\circ} 59'$	$\pi = 290^{\circ} 48'$
$\varpi = 138^{\circ} 51'$	$\varpi = 138^{\circ} 2'$
$i = 115^{\circ} 11'$	$i = 113^{\circ} 34'$
$q = 0.966$	$q = 0.963$

Mr. Denning, at Bristol, on August 11 and 12 thought the display weaker than usual ; but the observations were incomplete and the weather not favourable.

The shower was watched at a great many other stations, the atmospheric conditions being suitable and the sky moonless.

Orionids.—These meteors were well seen on October 18 at the University of Virginia, U.S.A. Mr. C. P. Olivier and two other observers noted 115 meteors, including 75 *Orionids*, in a watch of about five hours, and the mean place of the radiant was at $92^{\circ} + 16^{\circ}$. The shower was not quite so numerous as usual, and was remarkable for the general smallness of the meteors.

Leonids.—This shower returned with moderate activity on the morning of November 15, and was widely observed, the weather at about this period being very fine, though fogs were prevalent at times. The maximum occurred on November 14, between 16^h and 19^h G.M.T., and probably nearer the earlier hour, but it is difficult to define it exactly. At Greenwich, Meltham, near Huddersfield (C. L. Brook), and Charmouth the maximum seemed to have been indicated between 16^h and 16^h 15^m, but at Harvard College Observatory the numbers rapidly increased until in the 9 min. preceding 14^h (G.M.T. 19^h), with three observers, the meteors were coming at the hourly rate of 134, after which the shower exhibited a marked decrease in intensity. In England the rate of apparition seems to have increased from about 10 *Leonids* per hour (one observer) at midnight to 25 per hour at about 14^h, and to 60 or 70 per hour at about 16^h. But it is certain from many observations at home and abroad that during the next three hours (up to 19^h) the *Leonids* continued very numerous and included many brilliant objects, though the meteors generally do not seem to have equalled the average brightness of those seen on 1903 November 15.

The following are a few extracts from individual observations :

At Greenwich fog began to obscure the sky after 16^h₂ November 14, so that though the maximum number of meteors was observed between 16^h 5^m and 16^h 10^m the greatest intensity of the shower may really have occurred later.

Mr. C. L. Brook, near Huddersfield, on November 14, 16^h to 18^m, counted 69 *Leonids*, of which 17 appeared in the first quarter of an hour of the watch.

Mrs. Arthur Brook at Charmouth, on November 14, 12^h to 17^h 30^m, observed 144 meteors, of which about 115 were *Leonids*, and the maximum occurred between 15^h 50^m and 16^h 20^m, when the rate was at least one per minute.

Mr. W. H. Pickering, at Harvard, U.S.A., reports that on November 14 three observers saw 275 meteors, including 183 *Leonids*. At about midnight the horary rate was 15 : this had risen to 134 just before 14^h, and was about 40 until 15^h, after which it was 27 for one observer. The times are Eastern Standard, and are 5^h slow on G.M.T. Only one *Leonid* was photographed at Harvard, whence Mr. Pickering concludes that only very bright or very slow meteors are capable of making an impression on the plates.

At the University of Illinois the following numbers were counted by Mr. J. Stebbins :—

Nov. 13	h m	to	h m	C.S.T.	<i>Leonids</i> .	Other Meteors.
	13 5		17 5		18	21
14	13 0	„	17 0	„	44	42
15	12 50	„	17 0	„	23	20

Very few *Leonids* were seen anywhere on the nights following November 13 and 15, and the maximum, such as it was, decidedly occurred on November 14 ; but it was not more than one-fourth the richness of the *Leonid* shower of 1903. The recent display is, however, very interesting, for the parent comet (Tempel 1866 I.) passed through perihelion in 1899. There were pretty abundant displays in 1838 and 1871, five years after the brilliant maxima in 1833 and 1866, and the *Leonids* of 1904 probably represented a return of the same group.

Andromedids.—The Rev. W. F. A. Ellison, of Enniscorthy, observed what appears to have been a well-marked return of the *Andromedids* on November 21. At 7 P.M., though the Moon was nearly full, he saw 8 meteors in 15 seconds, and during the hour from 7^h to 8^h there were 24 altogether, and from 8^h to 9^h 22 more, but few afterwards on the same night, though meteors from the same radiant continued to fall until November 28. The radiant was at about 21° + 50°.

Geminids.—Mr. A. Sullivan, Dundrum, Dublin, observed this shower on the night of December 12, when between 10^h 17^m and 11^h 15^m G.M.T. he counted 20 *Geminids*.

The following is a list of the real paths of several bright meteors observed in England during the past year :—

Date.	G.M.T.	Bright- ness.	Height at First. Miles.	Height at End. Miles.	Length of Path. Miles.	Velocity per Sec. Miles.	Radiant Point. α δ	Ob- servers
1904.	^h ^m							
Jan. 9	8 28	$\mathcal{A} - > \mathcal{A}$	60	41	27	6	$41^{\circ} + 5^{\circ}$	2
10	8 33	$\text{♀} - > \text{♀}$	67	31	43	21	$43 + 22$	2
15	9 22	♀	63	27	36	12	$*61 + 41$	2
June 20	9 56	♀	66	42	42	...	$*302 + 23$	2
Aug. 11	10 39	$\text{I} - \text{♀}$	75	56	33	35	$46 + 58$	2
Sept. 18	12 10	$> \mathcal{A}$	58	23	54	21	$13 + 7$	2
Oct. 8	7 0 $\frac{1}{2}$	$= \mathcal{A}$	66	25	82	10	$260 + 4$	3
Nov. 3	10 55	$2\frac{1}{2} \times \text{♀}$	70	23	73	14	$344 + 24$	6
14	16 25	$> \mathcal{A}$	88	44	59	46	$151 + 22$	3
15	14 40	$\left\{ \begin{array}{l} 3\frac{1}{2} \times \text{♀} \\ - = \mathcal{A} \end{array} \right\}$	86	40	88	...	$*31 + 20$	5
Dec. 18	4 38	$= \text{♀}$	81	30	64	32	$*337 + 60$	6
22	4 30	...	83	28	58	29	$*330 + 36$	6

A Low Perseid.—On August 12 Herr P. Götz, of Heidelberg, photographed, with two Voigtländer objectives near together, the trail of what appears to be a very low *Perseid*, the height varying from three to nine miles. But the parallax was too small for the deduction of accurate results, for the average heights of the *Perseids* are from 80 to 54 miles, and of the *Leonids* from 84 to 57 miles. The *Perseids*, *Orionids*, *Leonids*, and other meteors of the swift, streaking type very rarely if ever penetrate our atmosphere sufficiently deep to get within 40 miles of the Earth's surface.

Meteorite of 1903 January 3.—A meteorite is stated to have fallen at 11^h 30^m P.M. at St. Mark's, Kaffraria, S. Africa. It gave a great glare of light, and four loud explosions accompanied its descent. The meteorite appears to have broken into two, one fragment of which fell obliquely in a field, making a hole two feet deep and being found on the further edge of it. The stone is black, slightly fused on the surface, and on one side are a great number of lines radiating from the centre. Its weight is 30 $\frac{1}{2}$ lb.

W. F. D.

Total Solar Eclipses.

1904 September 9.

The central line of the eclipse of 1904 September 9 was confined to the Pacific Ocean. No observation of it was made.

* Radiant points not precisely determinable from the incomplete or discordant character of the observations.

1905 August 30.

The eclipse of 1905 August 30, with a path traversing Labrador, Spain, Algeria, Tunis, and Egypt, is of considerable importance owing to the fact that it is the last that will be visible from any readily accessible parts of the Earth's surface for many years. For this reason it is hoped that adequate arrangements will be made for its observation at various places along the central line.

It is also notable owing to the long interval of time— $2\frac{1}{2}$ hours—between totality at points situated towards the extreme ends of the path in Labrador and Egypt. Large scale photographs taken at the western and eastern stations should throw light upon the vexed question of the rate of change in shape of the coronal rays and streamers.

It will be remembered that in 1893, when there was a gap of $1\frac{1}{2}$ hour between totality in Brazil and in West Africa, an examination of the photographs taken with similar instruments disclosed no perceptible change of form.

Since then there has been no eclipse where pictures separated by any substantial interval of time have been secured. Moreover, on this occasion it is expected that instruments of considerable focal length will be used both in North America and in Egypt, so that the comparison of their resulting images cannot fail to be interesting.

The Joint Permanent Eclipse Committee are arranging to send five parties of observers, who will occupy stations in Spain, Algeria, and Egypt; and it is hoped that the Royal Observatory, Greenwich, will send a party to Algeria.

The proposed observations comprise an extensive programme of spectroscopic work, both with slit spectroscopes and with objective prisms of long focus and of dispersion considerably greater than have been before employed; of polariscopic work with Iceland spar prism; of determinations of the coronal radiation with a bolometer; of photographs of the corona with instruments of long and short focus, and other work.

In addition to the official parties there will doubtless be a large number of observers sent out under the auspices of the British Astronomical Association and other bodies. The facility of the journey to Spain and the fact that the eclipse falls in the summer vacation will render it easy for astronomers to take this opportunity of viewing a phenomenon which will not recur, under such favourable conditions as regards accessibility, for nearly a decade.

E. H. H.

Solar Activity in 1904.

Sun-spots.—The character of the sun-spot record for 1904 may be very briefly summarised. There has been a slow, steady increase in the numbers and areas of spots without any striking incidents. There have been no days upon which the Sun has been observed to be free from spots; there have been no spot-groups of the first rank of importance. No single month has shown anything like the activity observed in 1903 October; no single group has approached that of 1903 October 5–17 in area. But there has been a slight but steady progress throughout the year, so that the mean daily area for the year is a little above that for 1903; the figures will probably work out as about 470 millionths of the Sun's visible hemisphere, as against 339 for 1903. This indicates an exceptionally slow advance; an area of at least 1000 might have been expected so long after the minimum if the precedent of the two preceding cycles had been followed.

Faculae have behaved much in the same way as sun-spots; that is, they have shown a steady, persistent, but slow increase without any very striking incidents. But their rate of increase has been less slow than that of the spots, and their mean daily area for 1904 will not come very far short of doubling that for 1903, or will be about 1700 millionths as compared with 969.

The mean latitude of sun-spots has undergone but little change during the year; but the higher-latitude spots have been dying out, and two or three small spot-groups have been seen within 10° of the equator.

The most important groups of the year appeared in April, and ran their courses from April 9 to April 20, and April 21 to May 2.

E. W. M.

The Prominences.—The year 1904 has proved very favourable for observation, and 127 complete drawings of the solar profile have been obtained at Kenley. The mean daily number of prominences again shows a marked increase, the general activity for the year being nearly twice that of 1902—a year of minimum activity.

The mean numbers for the two hemispheres derived from observations on 88 days in 1903 and 127 days in 1904 are as follows:—

			1903.	1904.
North hemisphere	...	...	3'64	4'92
South	„	...	3'91	5'14
Total mean number per diem			7'55	10'06

Dividing the year into two periods of six months, the increase is found to be progressive, the total mean numbers

being 9.0 per diem for the first half and 11.0 per diem for the second half. The total increase of 33 per cent. shown by the above figures does not, however, apply to all latitudes where prominences occur, but is chiefly confined to the equatorial zone and a zone in mid-latitudes between 30° and 40° ; these zones have increased in a much greater ratio, whilst some regions in the Northern Hemisphere have actually decreased in activity.

Part of the general increase may be attributed to an advance towards the poles of the high-latitude prominences, which have thereby *reclaimed* a considerable area of the barren polar regions. These prominences now occupy the zones $+55^{\circ}$ to $+65^{\circ}$ and -55° to -70° , and these zones are still the most active regions on the Sun.

The general order of change in the prominence distribution as the sun-spot maximum is approached appears to be characterised by a great welling up of prominences in mid-latitudes, followed by an increase in the latitude of the high-latitude prominences, which seem forced by their rivals in lower latitudes to take up positions nearer to the poles. The present distribution conforms more nearly to that of 1892 than any other year since 1889.

Metallic prominences were very infrequent during the first half of the year, but later they increased considerably and reached a maximum frequency in September. On the 20th of that month the magnesium lines were strongly reversed in the upper chromosphere at almost all positions on the limb—a very unusual occurrence.

Many of the metallic prominences observed appear to be recurrences after one or more half-rotations; thus the following sequences have been observed:—

Date.	Limb.	Latitude.	Longitude.	Period.
(1) June 27	E	+ 44	285	3 rotations 27.83 days.
Sept. 18	E	+ 44	267	
19	E	+ 43	254	
(2) June 27	W	- 32 to - 46	105	3 rotations 27.67 days.
Sept. 18	W	- 30 to - 39	87	
(3) June 29	E	- 23	258	5 rotations Mean period 27.20 days.
Sept. 4	W	- 22	272	
21	E	- 22	228	
Nov. 12	E	- 24	262	

The decrease in rotation-period with decreasing latitude is here clearly indicated.

J. E.

A Comparison of the Features of the Earth and the Moon.

Professor N. S. Shaler, of Harvard, who commenced to study the Moon in 1867 with the Harvard 15-inch Merz refractor, has recently published in No. 1438 of the *Smithsonian Contributions to Knowledge* his views as a geologist on the processes by which the surface of our satellite has been moulded. He finds a continuous gradation from the largest to the smallest of the ring mountains, and classes them all as "vulcanoids," believing them to have been formed by a non-explosive ebullition of lava. He rejects the theory that the rise and fall of the lava was due to earth-raised tides, and also the theory that the vulcanoids were formed by the impact of meteorites. He, however, adopts the view that the maria were formed by the impact of bolides from five to ten miles in diameter as the only working hypothesis which in any way accounts for the phenomena. The principal mountain ranges are supposed to have been formed by the exudation of very viscid lava, sometimes, as in the Altai range, brought about by faulting. The low ridges on the maria are caused by the action of pressure in the crust. Valleys of the Alpine type are attributed to double faulting; the rills to cracks in the surface, formed at so late a period that they failed to reach a fluid stratum; the bright ray systems to incipient cracks through which vapours, condensing to crystalline material, have issued.

Professor Shaler will not admit the existence of any lunar atmosphere or any form of organic life, and he believes that the surface of the Moon was brought to its present condition before the Earth had even a solid crust.

S. A. S.

Double Stars.

To make this report continuous the work has been classified under the two heads "Observation" and "Calculation," as in previous years. Abbreviated titles have been used as follows:—

M. N. : *Monthly Notices R.A.S.*

A. J. : *Astronomical Journal.*

L. O. B. : *Lick Observatory Bulletin.*

A. N. : *Astronomische Nachrichten.*

Observations—

R. T. A. Innes. *M. N.* lxiv. 2, p. 130. Measures of 100 pairs with the 18-inch refractor at the Cape Observatory in 1903.

Rev. T. E. Espin. *M. N.* lxiv. 3, p. 238. A list of 15 new doubles with separation ranging from $2''\cdot7$ to $8''\cdot9$.

Rev. T. E. Espin. *M. N.* lxiv. 7, p. 675. Measures of 160 pairs with the $17\frac{1}{4}$ -inch reflector. These are Σ , $O\Sigma$, and h stars, and were observed during 1900-4.

Royal Observatory, Greenwich. M. N. lxi. 8, p. 789. Measures of double stars made with the 28-inch refractor in 1903. There are 280 pairs with separation under $2''$ and 150 wider pairs which include *Sirius* and *Procyon*, and 110 Struve pairs requiring recent measures.

Miller and Cogshall. A. J., p. 554. A list of stars marked double in the Albany zone 1° – 5° was formed, and 38 observed with the 12-inch refractor at Kenwood.

S. W. Burnham. Decennial Publications of the University of Chicago. These are measures of about 600 pairs of Struve, Herschel, South, which have been neglected, and pairs discovered by various observers which do not appear to have been observed. In effect it goes far in the direction of collecting and observing the odds and ends of double stars. During the work, which was done with the 40-inch Chicago refractor, a few new pairs were found, bringing Prof. Burnham's numbers from β 1291 to β 1308.

W. J. Hussey. L. O. B. 57 and 65. Prof. Hussey has continued his systematic search for double stars, and in each of these *Bulletins* he gives 100 new pairs, so bringing his total discoveries to 800. Most of these are close and difficult, at least 30 per cent. being less than $0''.5$ separation.

R. G. Aitken. L. O. B. 50, 61, and 66. These new doubles also are the result of systematic search with the 12-inch and 36-inch Lick refractors. They are similar in character to those found by Professor Hussey, at least 75 per cent. being under $2''$ separation. The total number now reaches 900.

M. Biesbroeck, "Observations d'Étoiles doubles et Discussion des Mesures." These measures and their discussion are by M. Biesbroeck (Ingénieur des Ponts et Chaussées), who had the use of the 15-inch refractor at the Brussels (Uccle) Observatory. The measures of these 360 pairs were made in 1903 and 1904, and are of a high order. The complete work was done and published in eighteen months.

Calculation—

Under this heading come two papers dealing with proper motions. In the *A. S. P.* February Professor Comstock selects 67 double stars in which the proper motion of the principal component is known, and the relative motion is presumably rectilinear. This enables him to obtain proper motions for the 67 fainter comites, which he has utilised to obtain a value of the apex of the Sun's way—viz. 297° and $+28^{\circ}$. The second paper is by Messrs. Furner and Storey in the *M. N.* 1904 March. The authors are endeavouring to find proper motions for a number of double stars, and then proceeding on the lines of Professor Comstock. Seventeen pairs are discussed and others are promised.

A. N. 3946. Herr Prey gives the masses of the components of 70 *Ophiuchi* as 0.32 and 1.28 time that of the Sun. This determination is from meridian observations, and it is to be noted

that the fainter companion has four times the mass of the brighter.

Orbits computed are—

A. N. 3955, Lohse	— <i>Sirius</i> ,	period 50.38 years.
A. N. 3970, Doberck	— <i>Castor</i> ,	" 347 $\pm$ "
A. N. 3970, Doberck	— ζ <i>Sagittarii</i> ,	" 21.6 "

Miscellaneous Information—

M. N. lxiv. 6, Plate 13. Fowler—Spectrum of Σ 2140 (a *Herculis*).

A. S. P. 99. Some nine years since Belopolsky found the fainter companion of *Castor* to be a spectroscopic double with a period of three days. The Lick observers now find the brighter star is a spectroscopic double.

B. A. A. xiv. 7, p. 280. J. E. Gore has a note on κ *Pegasi*, for which he gives the hypothetical parallax as ''0.106.

M. N. xlv. 2, p. 162. J. E. Gore discusses the relative brightness and hypothetical parallax of 48 binaries. He concludes that the relative brightness decreases regularly as the stellar type of spectrum moves from A to K, and at the same time the hypothetical parallax increases from ''0.44 to ''2.29.

Observatory, No. 347. Miss A. M. Clerke discusses seven nebulous double stars.

T. L.

Variable Stars.

In reviewing the work done in this branch of astronomy during the past year one cannot but be struck with the very large number of new variable stars which has been added to those already known. From Harvard College Observatory, in circulars issued during 1904, no fewer than 407 new variables are announced. These have all been found by the method of examination of photographs, a method which ensures rapidity and accuracy. Of them, 90 are in the *Orion* nebula, including 10 discovered from photographs taken by the late Dr. Isaac Roberts; 57 are in the small Magellanic cloud, 152 in the large one, 105 are in *Scorpio*, and 16 in *Sagittarius*. In addition to these many variables have been found by other workers.

It would seem that a stage has now been reached when observation of *all* the known variables is impossible unless it were carried out under a far-reaching organisation.

Dr. S. C. Chandler has published in the *Astronomical Journal* (No. 553) a "Revision of Elements of Variable Stars" contained in his well-known third catalogue, and in No. 560 of the same periodical "Ephemerides of Long-period Variables from 1903 to 1910." Both these papers will be invaluable to workers in this branch.

An important study of the spectrum of α *Ceti* has been made at the Lick Observatory, from which it would appear that the variation is due to causes within the star, and not to a companion.

Herr Ludendorff's observations of ϵ *Aurigæ* indicate that the

Algol type of variation may extend to a period of many years, instead of being confined to a few days.

The publications of the observations of certain long-period variables made at the Rousdon Observatory, and inaugurated by the late Sir C. E. Peek, will be found in the *Memoirs of this Society* (vol. lv.). The material thus placed by Professor Turner at the disposal of anyone undertaking a research in this department is of great value on account of the excellence of the observations and the care with which they have been reduced.

E. E. M.

Stellar Spectroscopy in 1904.

Nebulæ.—Upon the spectroscopy of nebulæ little or no direct work has been published in 1904. Miss Clerke, however, contributes an interesting note to the *Observatory*, 1904, p. 303, on "Nebulous Double Stars," calling attention to stars involved in nebulæ.

Messrs. Frost and Adams (*Astroph. Jour.* xix. 352) have re-determined the radial velocity of the *Orion* nebula in the neighbourhood of the three brighter stars in the Trapezium; mean velocity from 11 plates $+18.5$ km/sec.

New Stars.—Perrine (*Lick Obs. Bulletin* 38, vol. ii. p. 130, and *Astroph. Jour.* xix. 80) describes observations made on various Novæ, and records the remarkable fact that the nebular line at λ 501 is no longer visible in Nova *Aurigæ*. Curtis (*ibid.*) records visual observations of Nova *Geminorum* and the conspicuous appearance of the green nebular line in its spectrum. Dr. Becker has published (*Trans. R.S. Edinburgh*, XLI. ii. No. 10) an account of his work on the spectrum of Nova *Persei* as photographed at Glasgow.

Classification of Stellar Spectra.—Sir Norman Lockyer, in discussing (*Proc. R.S.* 73, 227) the "Temperature Classification of Stars," adduces new experimental evidence in the shape of photographs taken with a view of comparing the ultra-violet extensions of the spectra of various pairs of stars. The same writer has another note (*Proc. R.S.* 74, 53) on the relation between the spectra of sun-spots and stars.

In a note read before the Section of Astrophysics at the St. Louis Congress (*Astroph. Jour.* xx. 342) Professor Frost calls attention to the desirability of arriving at some generally acceptable system of classification.

Distribution of Stellar Spectra.—The *Annals* of the Harvard College Observatory (vol. lvi. No. 1) contain a discussion of the celestial distribution of 32,197 stars according to their spectra. The work is being continued.

Studies of Special Stars.—Professor Pickering (*Harv. Coll. Obs. Circ.* 76, and *Astroph. Jour.* xix. 287) communicates a list of twenty-two stars having peculiar spectra.

R. H. Curtiss (*Astroph. Jour.* xx. 232) gives results (with photographic illustrations) of preliminary studies of the spectra of *R Scuti* and *W Cygni*; and also (*loc. cit.* p. 172) of *W Sagittarii* (Schmidt's variable γ' *Sagittarii*), with photographic illustration of the spectrum.

Professor Fowler (*Proc. R.S.* lxxiii. p. 219) claims to have identified the flutings in the spectra of stars of Secchi's Type III. ("dark flutings sharp towards the violet and fading off towards the red end of the spectrum"), with absorption corresponding to the bright flutings which he records for the first time as observed by him in the spark and arc spectra of titanium, and attributed by him to either titanium or titanium oxide.

Sir N. Lockyer and Mr. Baxandall (*Proc. R.S.* lxxiv. 255) give results of a study of enhanced lines of titanium, iron, and chromium with solar lines—"Fraunhoferic spectrum" as distinguished from chromospheric. The same writers (*Proc. R.S.* lxxiv. 296) give further reasons for regarding lines λ 4089.1, 4096.9, and 4116.1 (called by them Group IV. lines of silicium) as being rightly attributed to silicium; and they support their contention [in opposition to M. de Gramont (*C.R.* 139, 188, and *Astroph. Jour.* xx. 233), who attributes them to air] by reference to stellar spectra, a photograph of ϵ *Orionis* being given in comparison with the bright lines evoked from a vacuum tube containing SiF_4 .

Messrs. Haschek and Kustersitz (*Sitz. ber. Wiener Akad.* CXIII. vii.) discuss the origins of many lines in the spectra of γ *Cygni*, α *Canis Minoris*, and ϵ *Leonis*.

Father Sidgreaves (*Monthly Notices R.A.S.* lxiv. 168) gives further details about the spectrographic study of β *Lyræ*, and deals with it also in his interesting lecture at the Royal Institution (*Proc.* 1904 January 22).

Radial Velocity of Stars.—Mr. Belopolsky (*Astroph. Jour.* xix. 85) publishes results of his measurements relating to six "Standard Velocity Stars" in connexion with the co-operative scheme of observations:

α Persei	(1902.86) -2.89 ± 0.4	γ Aquilæ (1902.91) -1.98 ± 0.4
β Geminorum	(1903.16) $+3.37 \pm 0.1$	ϵ Pegasi (1903.24) $+5.99 \pm 0.2$
α Boötis	(1903.36) -6.07 ± 0.4	γ Cephei (1903.68) -39.94 ± 0.6

Professor Lord (*Astroph. Jour.* xix. 246), in a paper dealing with possible variability in the velocity of η *Piscium*, gives his determinations of velocity for α *Cassiopeiae*, α *Arietis*, ϵ *Pegasi*, ϵ *Leonis*, α *Ursæ Majoris*, α *Boötis*, ι *Aurigæ*, η *Boötis*, δ *Cephei*.

Mr. W. S. Adams (*Astroph. Jour.* xix. 338) has determined radial velocities of six stars in the *Pleiades*, and finds one of them, *Maia*, variable, whilst the remaining five have positive values between 3 and 15 km/sec.

Professor Küstner (*Ast. Nach.* 166, 177) gives the radial velocities of eighteen stars in his account of the new spectrographic outfit at Bonn.

Messrs. Frost and Adams (publications Yerkes Obs. II. 143) have determined the radial velocities of twenty stars having spectra of the *Orion* type, and incidentally give the velocities of *α Arietis* -13.6 , *α Tauri* $+56.1$, *α Boötis* -4.3 .

Variable Radial Velocity.—The following stars have in the course of the year been found to exhibit signs of variable velocity in the line of sight :

	R.A. h m	Decl. ° ' "	Mag. m			
<i>α</i> Andromedæ	0 3	+28 33	2.1	Lowell	Slipher,	<i>Astroph. Jour.</i> xx. 146
<i>η</i> Piscium	1 26	+14 50	5.0	Emerson McMillin	Lord,	<i>Astroph. Jour.</i> xix. 246
<i>γ</i> Persei	1 56	+54 0	5.0	Yerkes	Frost and Adams,	<i>Astroph. Jour.</i> xix. 152
20 Tauri (Maia)	3 40	+24 4	4.0	"	W.S. Adams,	<i>Astroph. Jour.</i> xix. 341
<i>ε</i> Persei	3 51	+39 43	3.0	"	Frost and Adams,	<i>Astroph. Jour.</i> xix. 152
<i>θ</i> ₁ Orionis	5 30	- 5 29	4.8	"	Frost and Adams,	<i>Astroph. Jour.</i> xix. 153
<i>θ</i> ₂ Orionis	...	...	5.3			
<i>σ</i> Orionis	5 34	- 2 39	3.8	"	"	"
<i>ξ</i> Orionis	6 6	+14 14	4.4	"	Frost and Adams,	<i>Astroph. Jour.</i> xix. 154
<i>S</i> Monocerotis	6 36	+ 9 59	4.6	"	"	"
<i>α</i> ₂ Geminorum (Castor, bright)	7 28	+32 7	...	Lick	Campbell, <i>Pub. Ast. Soc. Pac.</i> xvi. 260	
<i>η</i> Hydræ	8 38	+ 3 46	4.3	Yerkes	Frost and Adams,	<i>Astroph. Jour.</i> xix. 155
<i>α</i> Libræ	14 45	-15 37	2.3	Lowell	Slipher,	<i>Astroph. Jour.</i> xx. 147
<i>σ</i> Scorpii	16 15	-25 21	3.0	"	"	"
X Sagittarii	17 41	-27 48	4.9	"	"	"
W Sagittarii	17 59	-29 35	4.8-5.8	Lick	Curtiss,	<i>Astroph. Jour.</i> xx. 172
Y Sagittarii	18 15	-18 54	5.8-6.6	"	Curtiss,	<i>Astroph. Jour.</i> xx. 231
<i>S</i> Sagittæ	19 51	+16 22	5.6-6.4	"	"	"
<i>τ</i> Vulpeculæ	20 47	+27 53	5.5-6.5	Yerkes	Frost,	<i>Astroph. Jour.</i> xx. 296
<i>ε</i> Capricorni	21 31	-19 54	4.5	Lowell	Slipher,	<i>Astroph. Jour.</i> xx. 148

Professor Frost and Mr. Adams (*Astroph. Jour.* xix. p. 356) point out that their measures of the velocity of *γ Corvi* (publica-

tions Yerkes Obs. II. 226) were made at times when the variable nature of it discovered by Campbell and Curtis (*Astroph. Jour.* xviii. 307) could not be inferred.

Dr. Vogel (*Astroph. Jour.* xix. 360) contributes a very interesting paper on β Aurigæ.

Pickering (<i>Sid. Mess.</i> 1891) gave the period of this spectroscopic binary as		3.9838
Rambaut (<i>Monthly Notices R.A.S.</i> li. 327) deduced from the same observations a period		3.968
Miss Maury (<i>Astroph. Jour.</i> viii. 171) in relating observations made in 1889-1898 gave a period		3.9838
Vogel finds from Potsdam observations a period		3.9599

which also fits Tikhoff's measurements of spectrograms obtained by Belopolsky at Pulkowa. With this period all the anomalies which Tikhoff found, and which led him to imagine that the system of β Aurigæ was highly complicated, disappear.

Orbits and Parallax of Spectroscopic Binaries.—

The orbit of ι Pegasi (period $10^d.2$) has been worked out by H. D. Curtis (*Astroph. Jour.* xix. 212) based on forty-three photographs; range of velocity +43 to -52 km/sec.

The parallax of α Centauri (period $81^d.2$) has been deduced by W. H. Wright and Dr. Palmer (*Astroph. Jour.* xx. 141) from three photographs of each component of the pair on the assumption that the observed difference of velocity (5.17 km/sec) is due to relative orbital motion at the epoch of observation, and can be wholly accounted for by Roberts's orbit of the pair.

An approximation to the orbit of W Sagittarii (period $7^d.6$) has been got, partly by graphical methods, by R. H. Curtiss (*Astroph. Jour.* xx. 172).

The orbit of δ Orionis (period $5^d.73$) has been determined by Professor J. Hartmann (*Astroph. Jour.* xix. 268) from forty-two photographs of the spectrum; range of velocity +133 to -67 km/sec. Deslandres had deduced a period $1^d.92$ from his observations 1900. Hartmann shows that a period three times as long satisfies all the observations well. He also notes the fact that the calcium line K does not indicate any variability of velocity (see also Deslandres, *Ast. Nach.* 166, 33).

Measurement and Reduction of Observations.—Dr. Hartmann (*Astroph. Jour.* xx. 338) describes an ingenious simplification in measuring and reducing spectrograms in the determination of radial velocities, avoiding all need to measure, record, and identify individual lines in spectra. The method is one that seems capable of extended application to measurement of many kinds of photographs.

Mr. R. H. Curtiss (*Astroph. Jour.* xx. 338) gives in detail a method which he has used at the Lick Observatory.

Miss Dobbin (*Astroph. Jour.* xix. 382) publishes a table of line of sight constants for 112 stars of the Orion type in the same form as Schlesinger's table (*Astroph. Jour.* x. 1).

Discussion of Standards of Wave-length.—The following papers relating to discussion of systems of wave-lengths have appeared :—

Messrs. Fabry and Perot	<i>Astroph. Jour.</i> xix. 119 and xx. 318
Professor Kayser ...	„ xix. 157 „ xx. 327
„ Crew ...	„ xx. 313
„ Hartmann ...	„ xx. 41
Mr. Jewell ...	„ xxi. 1

New Spectrographic Installations.—Mr. Slipher (*Astroph. Jour.* xx. 1) gives an illustrated account of the spectrograph mounted in 1901 on the 24-inch refractor of the Lowell Observatory. It is being carefully used, for planetary observations in particular. The reproductions of photographs of the spectrum of *Jupiter* (*loc. cit.* Plate III.) and of *Neptune* and *Uranus* (*Lowell Obs. Bull.* No. 13) show great promise.

Professor Küstner (*Ast. Nach.* 166, 177) began spectrographic work in the summer of 1903 with a three-prism spectrograph attached to the Bonn photographic refractor, 30 cm. (12 inches) aperture.

Mr. W. H. Wright (*Astroph. Jour.* xx. 140) reports the successful installation of the Mills expedition on the summit of Cerro San Cristobal at Santiago. With a three-prism spectrograph attached to a 94 cm. (30·7 inches) Cassegrain reflector he has detected variable radial velocity in five stars and a difference in velocity between the components of a *Centauri*.

Mr. Horace Darwin (*Astroph. Jour.* xx. 347) gives a brief description of an electric thermostat designed for the spectrograph attached to the 24-inch refractor at the Royal Observatory, Cape of Good Hope (see also *Proc. Phys. Soc. Lond.* xix. 64).

Loss of Light in Stellar Spectroscopes.—Mr. J. H. Moore (*Astroph. Jour.* xx. 285) has carried out investigations, suggested by Professor Campbell, relating to the loss of light by diffraction at a narrow slit. This paper is followed by another relating to loss of light by absorption and reflection in the 36-inch Lick objective.

H. F. N.

International Co-operation in Solar Research.

In the early part of 1904 Professor Hale drew attention to the advantages which might result from arranging some plan of co-operation among those engaged in solar investigations. At a time of sun-spot maximum in particular it is desirable that the Sun should be under almost constant observation. The subject covers a wide range, and is of a diversified character, including the observation of widened lines, photographs, and spectroheliographs. It is clear that to secure a continuous record of the spot phenomena, observations of the widened lines of all spots in a

F F

considerable extent of the spectrum, and continuous records by the spectroheliograph in the H and K lines and the lines of hydrogen, a very extensive scheme of co-operation will be necessary. The American Academy of Sciences, which had appointed a Committee of Solar Research, with Professor Hale as chairman, called together a conference at St. Louis on 1904 September 23. Delegates were sent from the astronomical and physical societies of Europe and America, the Royal Society and the Royal Astronomical Society being represented by Professor Turner. The conference passed a resolution "in favour of the organisation of a scheme of international co-operation in solar research which shall encourage individual initiative, provide suggestions for definite lines of work, and facilitate the collection of results for publication." A committee was appointed for the purpose of obtaining the support of the International Association of Academies. An international committee, consisting of one delegate from each of the participating societies, was appointed and authorised to invite at its discretion other societies and individuals to co-operate. A discussion took place on the formation of a provisional programme of observations, and at the conclusion a committee, consisting of Professors Hale, Schuster, and Arrhenius, was nominated to draw up such a programme.

The question of standards of wave-length and the advisability of revising Rowland's standards was discussed, and several memoirs presented which were referred to the International Committee. Owing to lack of time the question of the observation of solar eclipses was similarly referred.

Oxford and Meudon were suggested as places for the next meeting.

New Observatory at Mount Wilson.

For the purpose of making special investigations on the Sun a new observatory has been established under Professor Hale's direction at a height of 5886 feet on the summit of Mount Wilson, near Pasadena, California, U.S.A. The Observatory was erected by the aid of a grant from the Carnegie Institution, and is referred to in the *Astrophysical Journal* as an expedition from the Yerkes Observatory. There seems to be every prospect that the Observatory on Mount Wilson will be permanent; and from the presence of Professor Barnard and Mr. Ritchey it may be inferred that the observations will not be confined to solar research.

The principal instrument at present is the Snow horizontal telescope, constructed in the optical shops of the Yerkes Observatory: it consists of two plane mirrors—one of which is driven as a cœlostæt—which feed one of two long focus mirrors. These mirrors are of 24 inches aperture and of 60 feet and 145 feet focal length respectively, and are used with powerful spectro-

heliographs and spectrographs for the study of sun-spots and other solar phenomena.

The present staff of the Observatory consists of the Director (Professor Hale), with Mr. Ellerman and Mr. Adams, who are associated with him in solar and spectroscopic researches; Mr. Ritchey, who is in charge of the workshop and optical experiments; and Professor Barnard, who has taken to Mount Wilson the large doublet lens presented to him by Miss Bruce. The optical work conducted under Mr. Ritchey's supervision includes the fusing of quartz with a view to the possibility of making mirrors from it. It is hoped that the five-foot telescope constructed by Mr. Ritchey will be mounted on the summit; but this will involve in the first instance the widening of the trail up the mountain, which is at present too narrow to allow of the transport of the parts of the instrument. The conditions of residence at the new Observatory will be somewhat novel: the wives and families of the observers will reside in Pasadena, the observers themselves occupying "monastic" quarters on the summit while at work, and descending for brief week-end visits.

Note added later.—The Observatory has now been definitely placed under the Carnegie Institution, and is named the "Solar Observatory," Mount Wilson, California. All letters should be addressed to "Observatory Office," Pasadena, California.

The Astrographic Chart and Catalogue.

A footnote in last year's report (see *Monthly Notices*, vol. lxiv. p. 374) stated that four fascicules of the Astrographic Catalogue had been received from the Algiers Observatory. These, with four fascicules from the Toulouse Observatory and a volume containing the measured rectilinear co-ordinates of the stars on half the plates of the Greenwich zone, *i.e.* the plates which cover the zone of declination from 64° N. to 72° N., form the total of the results of the work published last year.

The publications of the French observatories are similar in form and in most of their details to the volume previously published by the Paris Observatory. Essential points in which the English catalogue differs from the French arise from the fact that at Greenwich two plates, or rather portions of two plates, which cover the same area of the sky are measured together in the "duplex" micrometer, and hence each plate is measured only as far as the lines in which it intersects the adjacent plates whose centres have the same declination, or differ from it by two degrees, north and south, whereas all the stars on each of the plates taken at the French observatories are measured. As a result of this the Greenwich catalogue contains two measured positions and only two of every star; but in the system in which each plate is measured separately and

entirely, the same star can occur four or even five times, and it appears in the printed catalogue each time with a different designation, for in this system the stars are numbered consecutively, beginning with unity, on each plate. In the English system each star is known by the number of the zone of declination in which it occurs and its number in that zone. With the duplex micrometer measurement is made by means of a scale in the eyepiece, divided into tenths and hundredths of a *réseau* interval (300''), and the co-ordinates in the Greenwich Catalogue are given in terms of a *réseau* interval to the fourth decimal. The French plates are measured by means of a micrometer screw, and the co-ordinates are given in millimètres also to the fourth decimal of the unit. In all cases the measured co-ordinates are given uncorrected for scale value or for orientation of the plate. In the Algiers Catalogue, as in the Greenwich, no correction for possible errors of the *réseau* have been applied, but tables of such errors, when they are sensible, and of plate constants are given with other information in all the catalogues sufficient to convert these simple measures into Right Ascension and Declination. The French volumes give the constants together with the places of the stars in equatorial co-ordinates from which they are deduced on the same page as the plate to which they refer—a convenient method to which the Greenwich arrangement of printing does not lend itself—but in this work these data are collected in the Introduction. M. Trépied's (Algiers) Introduction is very complete, and gives an exhaustive *résumé* of astrographic geometry. M. Baillaud (Toulouse), as introduction to Tome IV., gives a description of his method of determining the magnitude of the stars on photographs by means of a wedge photometer.

The measurement and reduction of the Oxford University Catalogue Plates is completed, and the printing of this zone waits only for the provision of the necessary funds. At the Cape of Good Hope Observatory 760 Catalogue plates have been measured containing over 440,000 stars, and the measurement is proceeding at Sydney and Melbourne. M. Valle's report for the year 1903 states that the reduction of the measures is in hand at Tacubaya.

The weak link in the chain appears to be in the zone of declination 17° S. to 40° S. originally allotted to three South American observatories; part of this has been undertaken by the Perth (W. Australia) Observatory, and Mr. Cooke reports that 874 Catalogue plates have been taken, but no provision has been made for measuring them. He adds that "if the State Government remains in its present mood with respect to astronomical work the only thing will be to prepare the Catalogue piecemeal. There is no likelihood of making any measures during 1905." Another section of this zone has been undertaken by the Argentine National Observatory. The progress of the work done here was reported in the *Monthly Notices* for June last.

During the year enlarged copies of the Chart Plates (40

minutes' exposure) have been made at the Royal Observatory, Greenwich, by a photographic process already described (*Monthly Notices*, vol. lxiii. p. 132), and copies of 136 fields in the zones 65° , 66° , 67° have been distributed during 1904 to fifty observatories and other institutions. Similar copies, but made by heliogravure process, continue to be distributed by the French observatories, and the numbers at present received are, Paris 207, Algiers 176, Toulouse 107.

H. P. H.

Universal Time, Longitudes, and Geodesy.

From 1904 October 30 the time-ball at Hong Kong has been dropped by order of the Governor of the Colony at $17^{\text{h}} 0^{\text{m}} 0^{\text{s}}$ G.M.T., which is $23^{\text{m}} 18^{\text{s}}.14$ in advance of $1^{\text{h}} 0^{\text{m}} 0^{\text{s}}$ of Hong Kong mean time. This announcement, which at first sight seems unimportant, is actually the final step in a movement which has resulted in the adoption as standard of the time of the zone eight hours east of Greenwich in Eastern China and in the British Colonies, Hong Kong, Labuan, and British North Borneo, which come within its limits. It is probable that the time of the seventh hourly meridian will be adopted in Western China, but the exact line of delimitation is not yet settled.

A new time system has been proposed for India, Further India, and Burmah. The scheme suggested is that the times of the meridians $5\frac{1}{2}$ and $6\frac{1}{2}$ hours east of Greenwich should be adopted in these territories. No reason is given why hourly meridians five hours and six hours east should not be chosen; a plan which would bring the time of India into harmony with that of almost the whole of the civilised world.

During the year the definitive result of the longitude Potsdam-Greenwich determined by Professor Albrecht and Dr. Wanach, of the Prussian Geodetic Institute, has been published. The difference of longitude between the meridian of the transit room at the Geodetic Institute at Potsdam and the transit circle at Greenwich was found to be $52^{\text{m}} 16^{\text{s}}.051$, and the probable error of the determination $\pm 0^{\text{s}}.003$. It will be remembered that in this work star transits were recorded by means of Repsold registering micrometers, and it is worthy of note that the difference of personal equation of the observers derived from the observations is $0^{\text{s}}.000 \pm 0^{\text{s}}.005$.

By help of the result of a determination of the arc Berlin-Paris made in 1877 by officers of the Institute, Professor Albrecht deduces a value of the arc Paris-Greenwich $9^{\text{m}} 20^{\text{s}}.912$, or by using a value of the arc Berlin-Paris taken from *Bakhuyzen's Compensation* the difference between Paris and Greenwich arrived at is $9^{\text{m}} 20^{\text{s}}.887$.

The results of the direct determinations of the arc Paris-Greenwich made in 1902 have also been published. The value

found by the French observers is $9^m 20^s.974$, with a probable error of $\pm 0^s.008$. The English result is $9^m 20^s.932 \pm 0^s.006$.*

Mention may be made here of the result of the work of the Russo-Swedish expedition to Spitzbergen to measure the length of an arc of the meridian in a northern latitude, a summary of which was published in the *Bulletin Astronomique* for 1904 June. One principal fact determined appears to be that the distance between the parallels of latitude of Keilhau and Thumb Point is

$$272072^m.3 \pm 4^m.6$$

Latitude of Keilhau ...	...	⁰ 76	¹ 37	^{''} 44'6 $\pm$ 0'2
Latitude of Thumb Point ...	...	79	3	59'1 $\pm$ 0'3

In the calculations the ellipsoid of Bessel has been taken as base.

H. P. H.

* Since this has been in type, Professor Albrecht has combined the results of 176 telegraphic European longitude determinations among which these mentioned in this note are included to form a "Compensation." The definitive value for the arc Potsdam-Greenwich resulting from this is $52^m 16^s.062$, that of the arc Paris-Greenwich is $9^m 20^s.932$ (*Astronomische Nachrichten*, No. 3993-4, vol. 167, p. 157).

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Upsala Observatory.
Utrecht, Royal Meteorological Institute.
Vienna, Imperial Academy of Sciences.
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ADDRESS

Delivered by the President, Professor H. H. Turner, on presenting the Gold Medal of the Society to Professor Lewis Boss.

THE Gold Medal of the Society has been awarded to Professor LEWIS BOSS "for his long-continued work on the positions and proper motions of fundamental stars," and it is now my pleasant duty to lay before you the grounds on which the Council have made this award.

If, as we hope, our medals have been bestowed in recognition of the best work of the time, our list of medallists should be an epitome of the history of astronomy since the foundation of the Society in 1820. It is therefore satisfactory to find that one historical fact which is of importance in considering the work of Professor Boss is clearly brought out by this list—viz. that the need for observations of places of the fixed stars which characterised the earlier years has been gradually replaced by the need for careful discussion of the observations made. In 1820 our knowledge of the places of the stars rested chiefly on the work of Bradley, which was more than half a century old; so that the effects of precession and of proper motion, the former of which was only approximately known and the latter scarcely at all, were serious. More modern observations were sadly needed, and accordingly we find that the medal often went in those early years to the compilers of catalogues of stars—to Brisbane for observations at Paramatta, to Bessel for his zone observations, to Johnson for his Catalogue of 606 southern stars, to Wrottesley for his Catalogue of the R.A.'s of 1318 stars, to Argelander, to Rumker, and to Carrington. Professor Boss has more than once remarked that "the period 1820-1850 is richer than any other in the history of astronomy in fundamental determinations of a high class" (*A. J.* No. 423, p. 116).

But as observations accumulated the merits of such work were not ranked so high. Carrington was the last to receive, in 1859, a medal for a catalogue of stars of the fundamental kind; and already it had been practically recognised that the second historical period in fundamental astronomy had commenced. By comparing their observations with those of Bradley, astronomers determined the movements of the stars, not only the individual

proper motions, but the general apparent motion which we call precession, and ultimately the systematic drift due to the motion of the solar system through space. Thus in 1850 Otto von Struve received the medal for his paper on the constant of precession ; in 1852 we find the name of C. A. F. Peters, with a reference to his determination of nutation ; and in 1858, in awarding the medal to the Rev. R. Main, the President of the day specially referred to the proper motion of the solar system, which, Mr. Main conceived, "ought to be admitted among the established facts of astronomy."

As one catalogue after another was compared for purposes of this kind with Bradley's observations it became more and more important to make sure that these observations, which were adopted by universal consent as the starting-point of all such inquiries, were reduced in the best possible way ; and accordingly we find from our list that in 1888, so recently as to be within the memory of many here present, our medal was awarded to Professor Arthur Auwers "for his re-reduction of Bradley's observations."

The present award reminds us that the second period has in its turn been succeeded by a third, which discards Bradley's observations as the starting-point. The name and fame of Bradley are dear to us not merely because he was an Englishman, and represented England as Astronomer-Royal, but because of the greatness of the man himself. But however loth we may be to leave the old tradition which is rooted in Bradley we must recognise that we are come to the parting of the ways. Our medallist of to day struck out the new path in his first great work a quarter of a century ago, and has trodden it steadily ever since. Dr. Auwers, who paid the tribute to Bradley of re-reducing his observations in order that they might yield their utmost, and who has plodded steadily and loyally along the old highway to the very last, has recently* retraced his steps to the turning, and taken the new road along which we all must travel for the future.

I should pay a poor compliment to our medallist if I allowed a possibility of existence to the misconception that the modern views involve any disparagement of Bradley himself. He would, I am sure, defer to no one in his admiration for Bradley's greatness, and for the splendid results which he obtained from the instruments of that day. It is the instruments alone that are in question, or rather about which there is no question. They were certainly inferior to those available in 1820, and it appears that the inferiority was so great that it is now preferable to use the observations of 1820 as a starting-point, in spite of

* In his most recent rectification of the Fundamental Catalogue of the Berlin *Jahrbuch*, under date 1903 November 1, Dr. Auwers bases the declinations on fifty series with epochs from 1821 (Bessel) to 1897 (Munich and Ottawa). See *Ast. Nach.* No. 3927, p. 231, paragraph 3.

Bradley's great skill as an observer and his greater antiquity.* Parallel situations have arisen in other departments of astronomy. For instance, until recently it was considered that the mean motion of the Moon and its changes could be best evaluated by starting from the naked-eye observations of ancient eclipses and comparing these with modern observations. The time elapsed since the invention of the telescope has made more accurate observations possible is too short—so it was considered—to give us information which would compare in value with that furnished by the much longer interval. But recently we have found reason to doubt the soundness of this view. The ancient observations are affected by uncertainties of historic record, and it seems even possible that modern observations can be used rather to correct the old records and identifications than that these can add anything to what can be obtained from comparatively recent work. And so in the case of Bradley's observations, which stood as the foundation of accurate work for so many years, it would now seem that modern observations can rather tell us what were the division errors of Bradley's circle than that we can learn any new facts by retaining the results obtained from this imperfect circle as a starting-point.

Such, as I have stated, was the view propounded with great courage and ability by Professor Boss in 1877 or earlier. I do not know what was his age at that time, but to judge from his present vigour he must have been a young man; and we have confirmatory evidence of this in the fact that he was only the Assistant-Astronomer attached to the United States Northern Boundary Commission. The great work which has become classical under the name of *Boss's Declinations* appeared in the comparatively humble guise of Appendix H to the Report of this Commission, prefaced by a brief letter from the Assistant-

* Perhaps the following extracts from Professor Boss's writings of a later date put his position in a clear light. The italics are mine :—

" . . . No one would now think the instruments which Bradley used at all suited to the delicate task of precise determinations of star-positions. Observations made with them at the present time would be so distrusted for the possibility of anomalous systematic error that it is doubtful if they would be given any weight in comparison with the best contemporary observations. The distance in time and the isolation of Bradley's observations give them a real value, but their actual precision then is no greater than it would be now.

" . . . The trouble is, that for observations like those which were made with the rude instruments of past times *even by the greatest of observers*, it is impossible to arrive at more than a rough approximation to the systematic errors which they contain (*Ast. Jour.* No. 423, p. 115, 1898 January 3).

" . . . The object-glass of Bradley's transit was not achromatic, and the effective aperture employed was only $1\frac{1}{2}$ inch. Only one (coarse) transit wire was usually observed, and thus it requires no vivid imagination to call up apprehensions even more grave and forbidding than those which Professor Newcomb has entertained in regard to the older observations of faint stars. . . .

" . . . Bradley observed with his transit fully exposed to the Sun's rays : and there was not much improvement in this respect until long after his time. . . . His transit weighed only 55 pounds, and was 8 feet long with an axis $4\frac{1}{2}$ feet in length " (*Ast. Jour.* No. 430, p. 171).

Astronomer to his chief apologising for the "unexpected delay" in transmission.

In the Introduction following this letter it is explained that the latitudes of twenty-two stations in the vicinity of the 49th parallel, which separates the United States from Canada, depend on two factors—the accuracy of the observations made and the correctness of the declinations adopted: that the former might be considered beyond reproach, and that it therefore became necessary to examine the latter. To make the declinations as trustworthy as possible all the authorities which could be obtained from the library of the United States Naval Observatory had been consulted; that a comparison of these various catalogues *inter se* was naturally suggested; that the scope of the work gradually enlarged, until the final outcome was the volume in question, containing an exhaustive discussion of nearly one hundred fundamental catalogues, tables for the systematic correction of them all, and a final catalogue of the declinations and proper motions of 500 stars for the epoch 1875, which at once took a place in the very front rank. To emphasise the special characteristic of this work to which I have already called attention I will quote the following paragraph from the "preliminary statement":—

It will be shown that the interval of time between the group of early determinations by Bessel (1821), Struve (1824), and Argelander (1829), and the later ones at Leiden, Melbourne, Greenwich, and Washington Observatories (not to mention intermediate catalogues), is quite sufficient for an independent judgment as to the approximate accuracy and consequent weight of Bradley's results, and that a reliable system of corrections to the various catalogues may be founded on a discussion of recent catalogues alone, taking as the earliest that of Bessel for the mean epoch 1821 (p. [7] or 413).

We have been led to believe that our cousins in the United States regard their boundaries somewhat seriously. There is a well-known story, scarcely, however, suitable for repetition from this Chair, which assigns as one boundary the North Pole, and as another the Day of Judgment. But I venture to think that even these ideals, after making due allowance for the national love for picturesqueness of statement, scarcely surpass in magnificence the conception of duty which led a young assistant astronomer, in the ordinary course of his work on a Boundary Commission, to undertake, as Appendix H to the Report, the collation and revision of all existing catalogues, and to initiate a totally new departure in principle which the world has now adopted some quarter of a century later.

In an Address like the present it is impossible to follow this work in detail; but the brief description already given is doubtless sufficient to convey an idea of the colossal labour involved and of the energy of the man who could carry it through. Before passing on to his other work, however, I will add, by way of emphasis, his own description of his attitude at the

conclusion of his exertions. He proceeded by the method of successive approximations, which involved going over the whole material at least twice; and so little was his ardour damped by this repetition that he says at the end of it:—

It would have been for me a pleasant task to have undertaken, with the help of the places now available, a third approximation to the systematic corrections and weights. But the real object of the work has been already sufficiently accomplished, and the time is not at my disposal for the purpose (p. [164] or 570).

He had in fact been appointed, during the course of the work, Director of the Dudley Observatory at Albany, a position which he still holds, and which he has made famous. We can readily understand how, in the early years of such an appointment, his attention was claimed by matters more directly relating to the Observatory, and especially by the Albany zone observations ($+0^{\circ} 50'$ to $+5^{\circ} 10'$), which were undertaken according to the plan of the *Astronomische Gesellschaft*. This work was commenced in 1878 August, immediately after the return of the Director from observation of the total solar eclipse of that year, and claimed his attention for nearly a dozen years in all. Considering that during this time Professor Boss took charge of a transit of *Venus* expedition, and executed many other pieces of work; that he seldom had more than one assistant of any kind, and sometimes none at all; and that the zone observations were made and reduced in no mere perfunctory or superficial manner, but with the thoroughness characteristic of all his work, we may well marvel that it was completed so soon.

In illustration of this thoroughness it may be cited that in 1879 and 1880 the division correction required by each of the two circles employed for the observations, as well as the flexure of each, was investigated "by extremely laborious series of observations," although the knowledge thus obtained was not actually required in carrying out the strict programme of the *Astronomische Gesellschaft*, which demanded differential observations only. Well-marked flexures were found for both the circles, amounting to about a second of arc at maximum. The magnitude-equation was also carefully determined by observations with gauze screens; and, as we might confidently expect in Professor Boss's work, all available catalogues were compared with his observations, and a most valuable series of proper motions was deduced for the stars in this zone.

From a discussion of these he was led to the unexpected result that the effect of the Sun's motion through space is well marked among stars of the ninth magnitude, though it might naturally have been supposed from their faintness that these stars were too far away to show this perspective effect. Following up this clue, Professor Boss made two determinations of the solar motion from the slender material afforded by his observations—one from stars of mean magnitude 6.6 and another from

those two magnitudes fainter. He found that the Sun's apparent angular velocity came out nearly the same for both series, and was thus led to the startling conclusion that for the stars considered "the true criterion for estimating their average distances is very nearly independent of the magnitude, and that it is almost wholly some function of the apparent proper motion." This fundamental fact, obtained from the discussion of observations necessarily restricted to a narrow belt of the heavens, was soon afterwards* confirmed by Dr. Oscar Stumpe, using independent material applicable to the whole sky.

On the completion of the Albany zone, or perhaps even before it was finished, Professor Boss began to do what he could for the Southern Hemisphere by observing stars in the region -20° to -40° . It is among astronomers a well-known and deeply regretted fact that owing to the accumulation of observatories almost exclusively in the Northern Hemisphere our knowledge of the southern sky is far behind that of the northern. Professor Boss was director of one of the numerous northern observatories, but he reached out southwards as far as possible, and did what he could to lessen the disparity. Moreover, though restricted as regards observation he was free as regards discussion; and he brought the same skill to bear on the collation of southern catalogues that he had formerly displayed for northern. In 1898 he published a systematic comparison of seventeen southern catalogues and a standard system of places and proper motions of 179 southern stars (*A. J.* Nos. 448-450). Three years later he was able to include a few more catalogues, and to deduce from southern stars a determination of the solar motion in space, which afforded satisfactory independent confirmation of the results found from northern stars, and brought out several minor features of interest (*A. J.* 499-501).

Meanwhile the Dudley Observatory had been, in 1893, transferred to a new site. The old Observatory was near a great railroad which skirted the hill at a distance of about 160 yards, and was in need of extensive repair. Miss C. W. Bruce, of New York, who has been a liberal benefactor to astronomy in so many directions, offered \$25,000 additional endowment for the institution on condition that the "friends and neighbours" of the Observatory should secure its removal to a new and better site. This condition was promptly met by the subscription of another \$25,000 by sixty-five individuals, nearly all of whom were residents of Albany; and the city itself gave land for the new site and \$15,000 in exchange for the grounds and buildings of the old Observatory. Miss Bruce thereupon increased her donations to \$35,000. Professor Boss thus found himself in a greatly improved position. He was able to superintend personally

* The conclusions of Professor Boss were published in the *Astronomical Journal* for 1890 March 14. Dr. Stumpe's research is dated 1890 June and is published in *Astronomische Nachrichten*, Nos. 2999-3000, under date 1890 October 21: it contains no reference to Professor Boss's paper.

the re-erection of his transit circle at the new Observatory, and took special pains with the foundations. The observations of southern stars, temporarily interrupted, were soon resumed; and the Pruyñ Equatorial of 12 inches aperture was added to the Observatory equipment by the liberality of the sons of the late Robert H. Pruyñ, formerly president of the Observatory Trustees.

But an important question arose in consequence of the removal. Could the meridian circle be regarded as essentially the same instrument as before? or had the inevitable small jars of travel produced alterations, too slight perhaps to be noticed by the eye, but serious for astronomical observations? One test could be applied which might afford at any rate a partial answer to these questions. We have seen that the division errors and flexures of the two circles were carefully determined at the old site: they might be re-determined after the re-erection for comparison with the former values. It is true that the labour involved was enormous, and might well have deterred a less resolute man than our medallist. To him it was a mere circumstance, and he entered upon the "fourteen months' convict labour for four persons"—as I have heard him describe it—without a thought of evading any portion of it. Rather did he improve the occasion by pushing the research further than he had done before. He was rewarded by the attainment of several conclusions of a far-reaching character; as, for instance, that larger circles than those usually provided might profitably be used in meridian observing (*A. J.* No. 383); that systematic errors as opposed to individual corrections are an important part of the total error of graduation, especially when the subdivisions are made by use of a scale; and that the determination of the individual corrections may indeed serve no useful purpose (*A. J.* No. 401).

But the most important of all was the gratifying discovery that neither the division errors nor the flexures had been sensibly changed by the journey from the new site to the old; for not only did this fact bear eloquent testimony to the accuracy and sufficiency of both investigations; not only did it render plausible the inference that the whole instrument might be regarded as unaltered, so that the observations might be resumed without fear of discontinuity; but it suggested the important corollary that a longer journey such as that to the Southern Hemisphere might be undertaken with equal probability of preserving continuity; for the jars met with on a long sea voyage need not be so serious as those encountered during the transport over a few miles of road. To this conclusion I shall recur later, as it has a special importance with regard to Professor Boss's views of the consolidation of stellar positions.

We have seen that he began with the discussion of northern stars and proceeded to deal with southern. Neither discussion, however, was altogether exclusive; that of northern stars was not complete without some reference to southern catalogues, and

vice versa. But gradually he was led to a general scheme of consolidation for all catalogues, both north and south, which is still engaging his attention, though he has already completed the first and most important stage, and published the results in a series of memoirs of which I shall presently speak.

But before doing so I would call your attention to the steadiness of purpose which runs through all the work of our medallist. The terms of the Council award, "his *long-continued* work on the positions and proper motions of fundamental stars," are particularly appropriate, for the work has been continued throughout his career as an astronomer. His appointment to the Dudley Observatory hastened the close of his discussion of the northern declinations, but only initiated his attack on the main problem from a new point of view. The restriction to zone observations, which might have swept the notion of fundamental discussion out of the thoughts of another, did not deter Professor Boss from deducing the constant of precession and the elements of solar motion in space from these same zone observations.

But it must not be supposed that he neglected all other work. The pages of the *Astronomical Journal* contain numerous papers by him relating to comets, both observations and ephemerides. I will venture to quote from one of these papers a few words which seem to me to indicate the characteristically wide sweep of his outlook :—

It had occurred to me [he says] that the theory of the September comet of 1882 possesses uncommon interest from more than one point of view, and that this interest may become very intense and extremely inquisitive during the twenty-seventh century, when the fragments of the comet shall successively make their next appearance at perihelion, and when the positions of comparison stars may be investigated with a degree of rigour unattainable at the present time (*A. J.* No. 226, p. 75).

Accordingly, he gives the positions of 465 comparison stars determined at Albany; and I will hazard the prophecy that when the astronomers of the twenty-seventh century come to investigate them they will give them the maximum weight for the epoch.

But he rightly judged that he could be of best service to astronomy by using the fruits of his ripe experience in the line of work he had adopted from the first, and that such work as could be done equally well by others should be left to others; and this position he has consistently maintained in reply to inquiries from those who found it difficult to understand the importance of fundamental discussions, and who looked rather for tangible discoveries. Thus it is related of him that when a member of his Board of Trustees confessed to some disappointment that no comets were discovered at the Dudley Observatory he explained what a drawback it would be to neglect his cherished work for such a purpose, but declared that he could

almost certainly discover a comet vicariously for them if they would supply a modest sum, which he named, for payment of an assistant. And this promise he was actually able to perform ! The money was promptly subscribed ; the assistant was engaged and instructed what to do and how to do it, and within a short time the notable Comet 1882 (a) was found. It was a bold stroke, but Professor Boss was playing for a big stake. He wished to obtain freedom to work in the way he believed to be most important for astronomy, while retaining the confidence and approval of his trustees ; and by taking a risk which he felt was not unreasonable he managed to secure this happy combination. We know at any rate that he has produced no lack of work after his own heart ; and that he has the cordial support of the board of trustees and the citizens of Albany generally we know from the ready way in which they subscribed the money requisite for the removal and renovation of the Observatory in 1893.

But we must now turn to the work which is occupying the attention of our medallist at the present time, and of which an important section has been recently published in a series of papers, originally printed in the *Astronomical Journal* and afterwards collected under the title "A Catalogue of 627 Principal Standard Stars distributed from the North to the South Pole, and derived through a Homogeneous Treatment of all available Observations," by Lewis Boss (Albany, N.Y., 1904). This work is to be regarded, the author tells us, as the exhibit of an intermediate stage of an investigation which is in progress, and which cannot be completed until further important series of observations, *especially in the Southern Hemisphere*, provide the basis for a more definitive computation. Indeed, it is characteristic of such work that it can never be completed in a final sense. The addition of new observations will always necessitate their incorporation with the old, and consequent slight modifications. But as the mass of material already discussed increases in bulk longer series of new observations will be required if any sensible impression is to be produced by their addition, and hence longer intervals of time will naturally elapse between revisions. Had our knowledge of the Southern Hemisphere been more complete the present discussion might be confidently expected to suffice for some considerable time.

The work is presented in six sections. The first gives the catalogue of places and proper motions, with comparisons with the Catalogues of Auwers and Newcomb ; the second and third describe the method of forming the right ascensions, with a discussion of magnitude equation ; the fourth describes the corresponding method of forming declinations ; the fifth discusses the declinations of Bradley in the light of these modern observations ; and the sixth gives general tables of weights and systematic corrections and notes relating to various catalogues, of which over seventy were completely discussed. Instead of attempting to deal with such a comprehensive work as a whole,

I shall content myself with special references to two points of general interest which will illustrate the character of Professor Boss's methods and the fundamental nature of the results obtained.

The first is taken from his discussion of magnitude equation. For the benefit of those whose work lies in directions other than fundamental astronomy I may briefly recall the fact that this refinement of what has long been known as personal equation was definitely * discovered by Sir David Gill in his discussion of the comparison stars for *Mars* in 1878, and has since that time occupied an ever-increasing share of the attention of astronomers. He found that when the observations made by two different observers were compared they differed by an amount which varied with the brightness or magnitude of the star compared. Hence the name "magnitude equation." As in the case of the older "personal" equation, this kind of error was first noticed in connexion with transit observations; but it has been sought and found in other directions, even in photographic measures, though the origin of the discrepancy is there essentially different in character. It seems probable that magnitude-equation has taken up a permanent position as a factor—and a very troublesome factor—in all astronomical measurement of great refinement.

But we are concerned immediately with the particular form of it which occurs in making transit observations, and which consists in the fact that the observer, watching the passage of a faint star over a wire, tends to record a later instant than he would for a bright star. I have used the definite word "later" advisedly, for it has been ascertained that, while the amount of lag for one observer is different from that for another, there is a general consensus to be late for faint stars, or, if we prefer the statement, early for bright ones.

It has been ascertained by Professor Boss that the peculiarity for a given individual persists in spite of very deliberate changes in method of observing. It is well known to transit observers that they may adopt one or other of two mental processes in pressing the electric key to record a transit: they may commence pressing slightly before the star reaches the wire, so that the contact may occur as nearly as possible when the star is centrally on the wire, or they may wait until the star is on the wire and then begin to press. The difference may seem trivial to those who have not tried it in practice, but it represents a very real change in method to the observer. Professor Boss devoted some months to changing his personal habit from one plan to the other, and succeeded to his complete satisfaction, but found that nevertheless his magnitude-equation remained unchanged (*A. J.* No. 516, p. 100).

But a much greater revolution than this has been made in the

* Argelander and Gould had suggested the probability of its existence, but these were mere conjectures.

observation of transits during the last century. Before these days of electric apparatus, when we merely press a button, there were the old days of eye-and-ear observing—a completely different method. Was there a magnitude-equation then? and was it of the same kind as in these days? If not, then the proper motions of stars deduced from a comparison of ancient and modern observations will be systematically different according as the stars are bright or faint; and this might lead to erroneous conclusions, for instance, about the distance of the faint stars as compared with bright; in other words, about the structure of the universe, for in such ways does our knowledge of the vast in astronomy depend upon our care of the minute. We must find out, if we can, what was the average character of magnitude-equation in eye-and-ear transits compared with its average modern value; and Professor Boss's conclusion, from an exhaustive discussion of all these catalogues, that for all practical purposes this troublesome source of error has remained unchanged* by the revolution in method is not only of the first importance, but particularly welcome.

As a second illustration I take, not one of the results obtained by him, but one of his methods of work—viz. his method of combining a northern and a southern catalogue so as to obtain a knowledge of the refraction at each Observatory, and to free the observations accordingly from errors of adopted refraction. I do not know whether Professor Boss was the first (in 1877) to use this method, which is now familiar. He makes no claim to originality for it in his writings; rather does he say that “this method of deducing conclusions as to the most probable value of the refraction constant for each of the sets of observations compared has been recognised ever since the time when accurate observations were first made in the Southern Hemisphere.” (*Catalogue of 672 Stars*, p. 63, or *A. J.* No. 540, p. 119.) But it may be worth recording that so eminent an investigator as Main, working well within the limits of time mentioned by Professor Boss, had not recognised the essential feature of the method; for in combining in this way observations at Greenwich and the Cape he “assumed that the constant of refraction is not affected by locality; that it is the same at the Cape as it is at Greenwich” (see *Monthly Notices*, vol. xviii. p. 126).

Now this assumption may be justified as regards the theoretical constant of refraction; but Professor Boss has truly remarked that in practice we are concerned with a value of this constant modified by the particular barometer or thermometer in use, or the way in which the latter is exposed; and hence we must regard each Observatory as having its own special constant. This does not, however, prevent us from combining the Greenwich with the

* *Catalogue of 672 Stars*, p. 55. It is of interest to remark that this conclusion was previously quite unexpected by Professor Boss himself, who had formed a strongly contrary opinion (see *A. J.* No. 423, p. 117, last paragraph).

Cape observations ; it only brings out the strength of the combination. Near the Greenwich zenith the Greenwich refractions would be sensibly the same, whatever reasonable value we assigned to the Greenwich constant, and the comparisons therefore leave us free for the evaluation of the Cape constant. Near the Cape zenith, similarly, the Cape refractions do not matter, and we are left free to determine those of Greenwich. The mutual accommodation is so complete that we are almost reminded of the classical instance of the united couple, one of whom could eat no lean, the other no fat. But there is one small flaw in the agreement. Refraction is not the only source of error in declination observations ; there are instrumental errors as well ; and these are necessarily entangled with the uncertainties of refraction. By heroic labour these instrumental errors may be ascertained ; but there are not many men who, like our medallist, will cheerfully embark on "fourteen months' convict labour" to investigate them. A less satisfactory alternative is to trust to the general elimination of these individual errors in the mean of a number of catalogues made with different instruments ; but we are here met by the difficulty that in the Southern Hemisphere the number of instruments is lamentably few, and in past years was fewer still ; so that the total number of southern catalogues available for combination with northern on this beautiful plan is very small. Hence we are now in a position to gauge the merits of a scheme which I know lies very near the heart of our medallist, and which it is only necessary to mention in order to recognise its great importance for fundamental astronomy. We have seen that Professor Boss has determined the instrumental errors of his Olcott meridian-circle with the utmost care on two occasions, obtaining results which mutually confirm each other. Moreover, the instrument was transported bodily to some distance between the determinations without apparent disturbance, so that the possibility of moving it without injury has been demonstrated. Why, then, should it not be transported bodily to the Southern Hemisphere, and a southern catalogue made with it for comparison with observations already made in the Northern Hemisphere, which may possibly be supplemented by others on its return ? In this way the uncertain factor in the combination of the two catalogues would be eliminated ; the instrumental errors would be the same in both cases, and would, moreover, be accurately known. The observations would be entirely free for the determination of the two refraction constants, and a system of star-places would result of an excellence hitherto unparalleled.

This, as I have said, is the scheme which has gradually matured in Professor Boss's mind during a life of concentrated work steadily directed towards one goal, though as yet he cannot foresee with satisfactory probability the provision of means for putting it into execution.

It may well excite our wondering admiration to find that our medallist, after the long and arduous labours I have so inade-

quately described to you, with work, too, in hand requiring unremitting attention at the present time, should be looking ahead, not to a period of well-earned leisure, but to a scheme of this kind which involves, not only considerable risk and anxiety, not only renewed assiduity such as a younger man might well shrink from, but exile from home for a number of years. There can be but one opinion as to the value of such an enterprise, and but one thought in the minds of all those anxious for the welfare of astronomy—an earnest hope that means and opportunity may be found for putting so noble a project into execution. We may be aware that we are thereby hoping that the work of our medallist, as it has been “long continued” in the past, shall be also long continued in the future; but at the same time we are aware that for such a man the hope is only another expression of a hope for his long-continued happiness.

At the beginning of this Address I referred to our list of medallists as in some sort an epitome of astronomical history during the past eighty-five years. One of the features of that history which gives us as Englishmen peculiar gratification, and which is faithfully reflected in this list, is the steady and rapid development of astronomical work of the first order in the United States. At the foundation of our Society it could scarcely be said to exist; at the present day its growth is so vigorous that for the third time within five years we have the privilege and pleasure of recognising the merits of an American astronomer. And I would remark upon the varied character of the work done, as exemplified in the last three awards to stellar photometry, to solar spectroscopic research, and to fundamental astronomy. We are in presence of no mere handful of rare exotics, all of precisely the same type and dependent for their existence on the provision of plentiful artificial stimulus, but of a healthy and vigorous garden. Not that artificial warmth, when it can be obtained, is for a moment to be disparaged. Last year we had an opportunity of admiring the magnificent work which had been fostered by the provision of a great telescope and a great Observatory; and we know otherwise how much of the advance of astronomy in the United States has been due to the munificence of private citizens. It is all the more satisfactory to recognise in the very existence of men like Chandler and Boss that work can also be done under very different conditions. Professor Boss received timely aid from Miss Bruce and from the citizens of Albany in the removal of his Observatory, but beyond this the greater part of his work has been accomplished with very modest financial means; which is a new reason for hoping that, now the time has come when he requires help of a kind which has so freely been accorded elsewhere, he may not be long in finding it.

The journey across the Atlantic at the present time of year is a serious one, and we hear without surprise, though with rather selfish regrets, that our medallists cannot interrupt their

work to undertake it. In their absence it has been a great pleasure to us to be honoured by the genial presence of Mr. Choate; and it is particularly kind of him to-day to spare us a few moments from the busy weeks preceding a departure which the whole of England unites in deploring.

(The President then, addressing the American Ambassador, said:)

Mr. Choate, in sending this medal to Professor Lewis Boss will your Excellency kindly assure him of our great admiration for his long-continued work and our deep sense of its fundamental importance for astronomy, and our earnest hope that means may be found for carrying into effect his splendid plans for the future?

The Jackson-Gwilt Gift and Medal.

The Jackson-Gwilt Gift and Medal have been awarded to Mr. John Tebbutt, of Windsor, N.S.W., for his important observations of comets and double stars and his long-continued services to astronomy in Australia, extending over forty years.

This gift has only twice been awarded previously—in 1902 to Dr. Anderson, and in 1897 to Mr. Lewis Swift. In announcing the award in 1897 the President of the day stated that, after some consideration, he had decided not to give an address in connexion with the award, and I shall follow the precedent thus set. But there can be no reason why I should not recall to your memory that Mr. Tebbutt began astronomical work in 1854, and is only now relinquishing it at the age of seventy; that amid surroundings which gave him little encouragement he has made regular and systematic observations during half a century, including, for instance, those of some 1400 occultations of stars by the Moon and valuable measures of double stars; that he has contributed over eighty papers to the *Monthly Notices*; and has, moreover, discovered several comets, including the notable ones of 1861 and of 1881, the orbits of which he computed from his own observations.

In handing this medal to the Secretary for transmission, with the gift, to Mr. Tebbutt, I will ask him to convey our hearty congratulations to the recipient on the accomplishment of half a century of single-handed astronomical work for which it would be difficult, if not impossible, to find a parallel, and our delight that Mr. Tebbutt should be entering upon the rare enjoyment of a thoroughly well-earned period of rest.

The meeting then proceeded to the election of Officers and Council for the ensuing year, when the following Fellows were elected :

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